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The Seventy-Seventh Meeting of the American Astronomical Society

By CURVIN H. GINGRICH

The first formal session of the seventy-seventh meeting of the American Astronomical Society was called to order by the president, Professor Otto Struve, in a very modern lecture room in the Northwestern Technological Institute, Evanston, Illinois, at 9:00 A.M. on Thursday, September 4, 1947. Those members who arrived in time on Wednesday took part in the informal open house which began at 8:00 P.M. in Scott Hall also on the campus of Northwestern University.

In opening the first session, Dr. Struve called attention to the fact that this was the third time that the Society had assembled at Northwestern University—in 1914, 1942, and now in 1947. He then introduced Dr. Harry L. Wells, the vice-president of Northwestern University, who welcomed the Society to the University and extended its hospitality to the members. He also mentioned the fact that in a sense Northwestern University and Dearborn Observatory were the cradle of the American Astronomical Society, because of the part played by these institutions at the time of the founding of the Society. He was followed by Dr. Oliver J. Lee who extended more specifically the welcome and the hospitality of Dearborn Observatory. Dr. Lee, having been the director of Dearborn Observatory for the past fifteen years, could do this with complete propriety and authority.

These pleasant formalities having been attended to, the presenting of technical papers was begun. With fifty titles listed, it was necessary to use the time scheduled for the papers without delay. The president admonished those giving papers to use only the allotted time, which was usually done. After several papers had been read, the president declared an intermission of five minutes, after which Dr. van de Kamp took the presiding officer's chair for the remainder of the session.

The taking of the Society photograph was scheduled for twelve o'clock. Soon thereafter, although the clouds were threatening and some rain had begun to fall, the photograph was made with excellent results. It is to be regretted that the size of the reproduced photograph does not permit including more of the background. The group of 139 persons was assembled in front of the façade of the main entrance to the beautiful and very extensive Northwestern Technological Institute, already mentioned. This building with its spacious corridors, its num-

erous class rooms, offices, and laboratories afforded abundant opportunity for exploration between the sessions.

The next session, designated as the business session, was begun at 2:00 P.M., with Dr. Struve again presiding. At the suggestion of the chairman, the audience stood in respectful silence while the secretary read the names of those members who had died within the past year. Those names are the following:

Henry G. Avers
Walter M. Hamilton
William L. Holt
William A. Luby
Josephine Robinson Roe
W. Carl Rufus
William B. Stearns

The secretary then announced that the ballot taken by mail had resulted in the election of new officers as follows:

Vice-President	1947-1949	Paul W. Merrill
Secretary	1947-1948	C. M. Huffer
Treasurer	1947-1948	J. J. Nassau
Member of Division of Physical Sciences, National Research Council	1947-1950	B. J. Bok
Councilors	1947-1950	C. D. Shane J. L. Greenstein P. M. Millman

Nominations for members of the nominating committee of the Society were then made and a ballot taken. The ballot resulted in the election of a committee of three as follows: Dr. Peter van de Kamp, *Chairman*, Dr. Lawrence H. Aller, and Dr. O. C. Wilson.

The secretary then read the names of the new members recently elected by the Council. The list follows:

Dr. Leendert Binnendyk, Sproul Observatory, Swarthmore College, Swarthmore, Pennsylvania.

Dr. Adriaan Blaauw, Sterrewacht, Leiden, Holland.

Dr. Yuin Chang, Harvard Observatory, Cambridge 38, Massachusetts.

Mr. Herbert W. Cornell, 4117 North Fifteenth Street, Milwaukee 9, Wisconsin.

Mr. Morris S. Davis, Yale University Observatory, Prospect & Canner Streets, New Haven, Connecticut.

Mr. Joseph L. Gossner, Harvard College Observatory, Cambridge, Massachusetts.

Mr. Norman E. Hansen, Berkeley Astronomical Department, University of California, Berkeley 4, California.

Mrs. Marjorie H. Harrison, Yerkes Observatory, Williams Bay, Wisconsin.

Mr. Karl G. Henize, Leander McCormick Observatory, P. O. Box 1667, University Station, Charlottesville, Virginia.

Dr. M. Migeotte, Ohio State University, Columbus 10, Ohio.

Mr. K. Rao, Yerkes Observatory, Williams Bay, Wisconsin.

Mr. Leon E. Salanave, Sacramento College, Sacramento 14, California.

Mr. J. Madison Showalter, Hotel Sovereign, 6200 Kenmore Avenue, Chicago, Illinois.

Mr. John Sternig, Deerfield, Illinois.

Prof. Bengt. G. Strömgren, Royal Observatory, Östervoldgade 3, Copenhagen, Denmark.

Miss Anne B. Underhill, Yerkes Observatory, Williams Bay, Wisconsin.

Gale Bruno van Albada, Warner & Swasey Observatory, 1975 Taylor Road, East Cleveland 12, Ohio.

Dr. Hendrik C. van de Hulst, Yerkes Observatory, Williams Bay, Wisconsin.

Prof. Lloyd R. Wylie, Wittenberg College, Springfield, Ohio.

Dr. C. S. Yu, David Dunlap Observatory, Richmond Hill, Ontario, Canada.

Professor V. Ambartsumian of Leningrad, U.S.S.R., was elected to honorary membership in the Society.

Several announcements of much interest to all present followed. They were:

1. The acceptance by the Council of the Jessie Stevenson Kovalenko Fund in the amount of three thousand dollars, established by Dr. Kovalenko as a memorial to Mrs. Kovalenko, to be used at the discretion of the Council.

2. The election of Dr. Michel S. Kovalenko as a patron of the Society.

3. The seventy-eighth meeting of the Society to be held in Columbus, Ohio, December 29-31, 1947.

4. The seventy-ninth meeting of the Society to be held in Pasadena, California, June 27-July 3, 1948. At this meeting the second Henry Norris Russell lecture will be given by Dr. Walter S. Adams on the subject "Clouds in Interstellar Space." Dr. Struve stated that these dates were earlier in the summer than usual in order to make it possible to attend this meeting and that of the International Astronomical Union in case it is decided to hold such meeting in Switzerland in August.

5. That the Council was in a receptive mood for suggestions as to places for the holding of the meeting in December, 1948.

The business session being concluded, the presentation of papers was resumed. As planned, the remainder of the afternoon was devoted to a symposium on "Stellar Atmospheres." The symposium consisted of papers by Drs. Strömgren, Keenan and Hynek, Struve, Aller, McKellar, and Joy. Other members participated in the discussion which followed. The session adjourned at 5:15. Before adjournment, Dr. Struve stated that an extra session was necessary to provide time for all the papers listed, and that such extra session would be held at 8:00 that evening.

This plan was carried out with Dr. John S. Hall presiding. It was a pleasant change to go from the humid, oppressive summer heat outside into the air-conditioned lecture room where coats were comfortable. The evening session was closed at 9:45 in order to comply with the regulation that everyone must be out of the building by 10:00.

The Friday morning session was called to order by Dr. Harold L.

Alden. At the outset he stated that the number of papers remaining was such that only 1.7 minutes could be allowed for the discussion of each one! As a result of this carefully planned schedule, the reading of papers was concluded in time for luncheon.

The Friday afternoon session was devoted to a Teachers' Conference with Dr. J. A. Hynek presiding. The teaching of celestial mechanics and of the computation of orbits was stressed. Papers were contributed by Drs. Brouwer, Herget, Clemence, and Whipple. Abstracts of these papers as well as of all the other papers read will appear as usual in the *Astronomical Journal,* hence we shall not give further details here.

The Teachers' Conference was concluded in time for the coffee hour at the Dearborn Observatory at 4:30 P.M. This and a similar occasion on the preceding day furnished refreshment of mind and body. The alternative to a cup of coffee was a cup of chilled fruit juice. Because of the persistent high temperature the latter seemed to be the favorite. While the fruit juices were disappearing in large quantities, the library and corridors of old Dearborn resounded with much conversation, and everywhere there was evidence of merriment and good cheer.

Friday evening was set aside for the customary Society dinner. A dining room on the sixth (top) floor of the Georgian Hotel, Evanston, was reserved for the occasion. The dining room opened upon a roof garden overlooking Lake Michigan. Before the dinner, the guests thronged about this elevated terrace and reveled in the coolness of the air at this distanec above the surface. After the dinner, Dr. Struve called upon Dr. Dirk Brouwer to tell of the organization of the Watson Astronomical Computing Bureau and of its availibility for those needing computations in their researches. He then invited Dr. P. Swings, recently returned from Belgium, to give an account of his impressions as to the probable future of astronomy in Europe. Dr. Struve then very appropriately and with well chosen phrases expressed the sentiments of the many friends of Dr. Oliver J. Lee on the occasion of his retiring from the directorship of the Dearborn Observatory. He spoke of Dr. Lee's important astronomical work both at Yerkes and at Dearborn, and extended to him and Mrs. Lee the congratulations and felicitations of the assemblage. Dr. Lee responded appreciatively, after which the formal part of the evening was concluded, although many remained to express personal greetings to Dr. and Mrs. Lee.

After a hearty breakfast on Saturday morning, the last of a series of enjoyable meals served at Lunt Hall, a procession of cars set out for Williams Bay. There was a chartered bus in the procession for those without other means of transportation. The change from Daylight Saving Time in Evanston to Central Standard Time in Williams Bay furnished an hour which was used for the journey. The party arrived at the Yerkes Observatory in time for the session which was scheduled for 10:00 a.m. The transfer from Dearborn to Yerkes Observatory was

made in order the more fittingly to celebrate the fiftieth anniversary of the Yerkes Observatory as well as that of the American Astronomical Society.

The library room of the Yerkes Observatory was filled to capacity at 10:00 o'clock. Dr. Struve called the session to order and presented Dr. Walter Bartky, Dean of Physical Sciences of the University of Chicago, who extended the official welcome of the University of Chicago. He mentioned the long-range vision of President Harper in accepting the Yerkes Observatory fifty years ago even though the financing of it created a serious problem at the time. He said that the basic research done at the Observatory paved the way for the present day development of the cyclotron and betatron. He advised any who might be contemplating starting a university to begin with an observatory!

Dr. G. P. Kuiper, the newly appointed director of the Yerkes and the McDonald Observatories spoke briefly concerning the occasion and the program for the day, after which Dr. Struve requested Dr. Joy to preside throughout the remainder of the session. Dr. Joy then called upon Dr. Joel Stebbins, Director of Washburn Observatory and for many years Secretary of the American Astronomical Society, to read the paper he had prepared pertinent to the fiftieth anniversary of the founding of the Society. This was followed by a paper by Dr. Struve relating to the history of the Yerkes Observatory during its first fifty years. These papers, essentially as they were given, follow this report, hence further comment concerning them is unnecssary.

Dr. P. Swings spoke briefly of a series of letters he is assembling from those of his European colleagues who have had contact with the Yerkes Observatory. We are planning to publish these letters later in POPULAR ASTRONOMY.

The group, 144 in number, then drifted leisurely to the George Williams College Camp on Lake Geneva where luncheon was served. After the luncheon, Dr. Joy, at the request of Dr. Kuiper, spoke of the present day activity in astronomy in Southern California, after which the fiftieth anniversary celebrations and the seventy-seventh meeting were formally closed.

Some started their homeward journeys immediately and others lingered about the Observatory and its surroundings and enjoyed the hospitality of a tea given by the Observatory on the shady lawn near the building. By early evening all guests had departed except those who planned to remain for the symposium on planetary atmospheres which was scheduled for the coming week, and the seventy-seventh meeting had become history and a pleasant memory. The general comment on the part of the guests was one of gratitude and appreciation of the careful thought which Dr. Lee, Dr. Struve and Dr. Kuiper, and their assistants had given to the arranging of the details for their comfort.

Occasions such as this doubtless are an important contributing factor to the rapid growth in size and interest in the American Astronomical Society.

The American Astronomical Society, 1897-1947*

By JOEL STEBBINS

We are celebrating, as announced, the fiftieth anniversary of the founding of this Society at the time of the dedication of the Yerkes Observatory in October, 1897. Many of you do not know that several weeks ago we had a rehearsal for today by a celebration of the fiftieth birthday of the incumbent president of the Society, who is also the chancellor, or whatever you may call him, of the Yerkes Observatory; so there is occasion for congratulations all around. Mr. Struve will discuss the history of the Observatory, while the present paper will be confined to the activities of the Society. It would have been much better if we could have had with us today someone from that first meeting. I am thinking of Henry Crew of Northwestern, Charles Lane Poor of New York, and Frederick H. Seares of Mount Wilson—three known survivors of the sixty scientists who gathered fifty years ago.

As you will remember, the meeting of 1897 was called as a conference of astronomers and physicists; and it was so successful that a second such conference was held on the invitation of Professor Edward C. Pickering at the Harvard Observatory a year later; and then in September, 1899, the formal organization was accomplished in another meeting at the Yerkes Observatory. The name adopted was "Astronomical and Astrophysical Society of America," giving emphasis to the fact that many physicists had interests in common with the astronomers. The organization continued under that rather unwieldy name for ten years when, again at Yerkes, a vote was taken on the change of name to the "American Astronomical Society." Out of deference to a few members who felt more at home under the old name, the decision was against the change; but five years later at Evanston, the designation, "American Astronomical Society," was adopted by a practically unanimous vote. This artificial distinction between the older astronomy and the newer astrophysics was more important in the early years of the Society than it is now. The time is long past when astrophysics could be considered a separate science. For illustration, the contributed papers on the program of the present meeting include not more than ten per cent of titles in the old time astronomy, and several of these are based upon photography.

*Read at the fiftieth anniversary meeting of the Society held at the Yerkes Observatory, September 6, 1947.

The objects of the Society were first stated to be the advancement of astronomy, astrophysics, and related branches of physics; and the qualifications for membership were as follows: "Any person deemed capable of preparing an acceptable paper upon some subject of astronomy, astrophysics, or related branch of physics, may be elected by the Council to membership in the Society upon nomination by two or more members of the Society." With the change of the name of the organization, the scientific fields were defined as astronomy and related branches of science. The qualification that a candidate for membership be deemed capable of preparing an acceptable paper has been rather liberally interpreted. The Council once received a letter from an applicant stating that he was not a lawyer for nothing; and he pointed out that the rule does not state acceptable to whom. He himself could prepare a paper which would be quite acceptable to the janitor for starting a fire. I believe that the Council ruled that the candidate's own letter could be construed as an acceptable paper. In other cases, it has been suggested that a good-sized check on a bank might be considered an acceptable paper on astronomy.

Joking aside, while the rule for acceptance of new members has been liberally applied, the acceptance of papers for the program has always been a serious matter in the Council. The fundamental test has, of course, been that a paper be sound. At the risk of non-appreciation of some genius by his contemporaries, any doubtful title is usually held by the secretary and, if necessary, an abstract or the whole paper sent to a referee before acceptance. However, there are very few such cases, and usually it is easy to tell from the source what the nature of a paper will be. For instance, as far as I can remember, and I am pretty sure I am correct, we have never had any crank papers from the Yerkes Observatory. At the other extreme would be the papers which the secretary would know better than even to refer to the Council, such as the recent communication on the Flying Saucers.

In 1899, one hundred and thirteen persons expressed the intention of becoming charter members. You may be interested to hear the names of the eleven known survivors from that list. They are: Charles G. Abbot, Walter S. Adams, Henry Crew, W. S. Eichelberger, H. M. Goodwin, W. J. Humphreys, A. C. Lunn, Antonia C. Maury, F. R. Moulton, Charles D. Perrine, and Robert W. Wood. Messrs Poor and Seares joined shortly afterward. As you are aware, a goodly proportion of these are still active in astronomical work; they average seventy-nine years of age. By 1922, the membership had increased to 370, while the present number is about 625. Thus we can count on a gain of about ten members per year with no present prospect of the number leveling off at a saturation figure. A rough analysis of the membership shows that about one-half are actively working at observatories; one quarter are connected with colleges, universities, or scientific institutions; while an-

other quarter are interested in astronomy without formal connection with institutions. Over the years, various suggestions have been made to have more than one class of membership; but all such movements have been voted down. We seem to be too happy a family to think of breaking up. We do have the class of Honorary Members under the rule that not more often than once each year the Council may elect one foreign astronomer of distinction to such membership. Since 1910, twenty-four honorary members have been elected, of whom eleven are now living. A glance at the list of names will show the leaders in astronomy in different countries during the past generation.

The main activity of the Society has, of course, been in connection with the meetings, which were first held annually; but since 1920 we have met twice a year. The present is officially the seventy-seventh meeting which, with the first two conferences, makes a total of seventy-nine. The reports of the papers presented at these meetings give the record of the advance of American astronomy during the last half century. A count of the places where the Society has met gives the following: Harvard leads with eleven meetings; followed by Columbia with seven; and Yerkes six, counting today. Five meetings have been held at Washington and at Philadelphia; and three each at Yale, Northwestern, and Chicago; also there have been two meetings each at Ottawa, Cleveland, Swarthmore, Michigan, Wisconsin, and Ohio Wesleyan. Twenty-two places have had one meeting each, so we have had plenty of variety. The count also shows forty-eight meetings east and twenty-five meetings west of the Alleghenies, plus three in California and three in Canada. About half of the gatherings were in cities and half in what may be called college towns, though here the count is rather arbitrary. We have placed Harvard and Yale in the college town category—at least they are in academic surroundings—and Yerkes is left out in the country. The Society has met twenty-two times with the American Associaion for the Advancement of Science, usually at the winter meetings and especially at the four-year general meetings, which were formerly held in rotation in New York, Washington, and Chicago. Various advantages accrue to an observatory or institution in entertaining the Society. The approach of the meeting usually means a certain amount of house cleaning and fresh paint in addition to the stimulated local activity in astronomy.

We may note some possibilities for meetings which have been proposed but not held. Someone suggested a three-day reunion on one of the steamers of the Great Lakes. The housing accommodations would be take care of, and the social life would be even more intimate than on a college campus. Those of us who are poor sailors would want to know what the weather would be like for three days in advance. The nearest we came to such an excursion was at the meeting at Put-in-Bay on Lake Erie in 1908. Again, there has been a minority enthusiasm for

Florida or New Orleans in the winter time, but such suggestions have been squelched. The majority of members have preferred to remain in the North and run the risk of a blizzard rather than to visit the sunny South. Either an exposition or an eclipse has been necessary to draw us out to California, and the 200-inch will be the attraction in 1948. Another fine place for a meeting, if we can ever get that far, is Victoria where those of us who have been there know that the local arrangements would be ideal.

As the Society has grown in numbers, the attendance at meetings has also increased, but fortunately not in proportion. From sixty attendants at the original Yerkes meeting, the number increased to 130 at the second conference at Harvard, a good attendance for any meeting at the present time. The largest attendance up to date has also been at Harvard when last winter more than two hundred attended the Society dinner, but only 165 were able to crowd into the photograph, which was surpassed by that of Yerkes six years ago when the number was 170. But all these figures are small compared with the group that attended the dedication exercises at Yerkes in 1897. In two special trains from Chicago, trustees, faculty, students, and guests of the University of Chicago to the number of 700 came to be entertained, fed, and enlightened in this building.

One complaint about the meetings has always been that if it hadn't been for the papers, we should have had a good time! There seems to be no substitute for this evil. The evil has been lessened somewhat by limiting the papers to ten minutes and enforcing the rule of one author, one paper; though practically the question often comes up as to how many papers may be presented by several authors in cooperation. One suggestion which has been advanced in dead earnest is that the program be limited to only good papers. Just who would decide in advance which are to be the good papers has not been worked out; and there is something to be said for the training of the younger members in preparing any kind of papers—even poor ones. In recent years, we have had more invited contributions at symposia, though long ago one member said, "Why do we do it? Each symposium is worse than the one before." He had in mind the length of a program where every author went overtime by at least a factor of two. With the gradual training of the membership, not to say of the presiding officers, the time problem has been approximately solved, but it will require eternal vigilance to keep astronomers from talking too long.

Speaking of officers reminds one of the old method of elections. Formerly at the annual meeting each member was entitled personally or by mail to a vote on a nominating ballot for every vacancy to be filled. On the last day of the meeting, the votes were then taken in succession for the different officers, the selection to be limited to those nominated for the particular office or for some higher office. On one

occasion the presiding officer pointed out that one good candidate, Mr. Frost of Yerkes, had been nominated for all the offices and that it would simplify the business of the Society if the members would proceed to elect him. Over the years the innocent phrase, "some higher office," had an unintended result. After the voting, which took considerable time, it almost always turned out that the same officers were elected as before; in fact, in the early years of the Society changes among the officers were very slow. In 1919, under the leadership of Ernest W. Brown, the new system was introduced. Brown had a hobby of reforming scientific societies; his idea being not only to devise the machinery for getting good men into office but also to make sure that they got out again. The procedure of having the nominations prepared by a committee insures that the officers and Council will be a representative group, taking into account such considerations as geography, age, and the different fields of astronomy. Under the present rules of limited terms more members of the Society are represented on the Council, and there is nothing like a feeling of possession to keep up the interest in an organization. Some criticism has been made of the three-year term of the president as being too long. The term is not long measured by the number of meetings—only six of them—but it means that two out of three of the annually elected vice presidents will be passed over. Perhaps the honoring of individuals should be subordinated to the best interests of the Society, and such matters as a campaign for funds and other important business of the Society could scarcely be directed by an officer in a term of one year. Since it is desirable to have continuity in the positions of secretary and treasurer, these officers are chosen annually with possibility of re-election pending good behavior.

It would be invidious to distinguish between officers and members who have contributed to the work of the Society, but there can be no objection to mentioning the presidents who have passed on. Simon Newcomb was elected as first president while he was absent abroad. He gave the Society the prestige of the foremost man of science of his time in America. I believe the record shows that he had between fifteen and twenty honorary doctor's degrees, evidence of the estimation in which he was held. Newcomb, himself, as you know, was largely self-trained; and he once expressed the doubt whether the next great student of celestial mechanics would come from a university or from the backwoods. He continued to serve as president for six years, when he retired at his own request. Following Newcomb was Edward C. Pickering, who dominated the meetings of the Society with his genial personality for fourteen years until his death in 1919. Pickering was an admirable presiding officer, and it was often remarked how he could bring out discussion of a paper, contributing himself with pertinent remarks in almost any field of astronomy. Frank Schlesinger was the first president to serve under the new rule of a three-year term. He

had long been active in the affairs of the Society, particularly as chairman of the Parallax Committee; and it was he who initiated the custom of two meetings per year. William Wallace Campbell was elected president of the Society just as he was taking over the duties of the presidency of the University of California. Despite the demands on his time, he did not hesitate to travel across the continent to preside at our meetings; and we remember how once, to be on time, he had to taxi fifty miles across New England, where trains run east and west on Sunday but not north or south. Campbell also headed the American delegation to the organization meeting of the International Astronomical Union in 1919 and was president of the Union at the Cambridge, England, meeting of 1925. George C. Comstock served as the first secretary of the Society for ten years and was chairman of the Committee on Comets at the time the Society sent an expedition to Hawaii for observations of Halley's comet. Comstock had legal training, and it was during his regime that the Society was incorporated. Ernest W. Brown introduced the reformed procedure for the election of officers, as we have mentioned before, and his interest in the Society was indicated by his bequest of two funds; one for the promotion of the Society's own journal when it should have one, and a fund for the Hollerith Computing Bureau. Brown's benevolent action led to some wag of a member saying that it should be a rule that every retiring president must leave a substantial bequest to the Society.

Although George E. Hale never held the office of president, it is no secret that the office was offered to him by a committee, but he had to decline on account of ill health. In addition to the observatories which Hale established, we name some of the scientific societies he was instrumental either in founding or reforming. Besides our own Society, they are the National Academy of Sciences; the National Research Council; the International Union for Cooperation in Solar Research, afterwards reorganized as the International Astronomical Union; and the International Research Council, since changed to the International Council of Scientific Unions. Lest Hale's other activities be overlooked, we must add his influence in the Huntington Library, the California Institute of Technology, and the planning of the city of Pasadena. As someone remarked, those of us who had the privilege of coming under Hale's influence will be telling our children and grandchildren that we knew such a man.

Many other members have, of course, rendered great service to the Society, but we must mention the donors of the different endowments. For a long time it looked as though the amateurs would get all the money around the country, but this situation is gradually being rectified. Besides the Life Membership Fund, to which we have contributed ourselves, there are the Annie J. Cannon Fund, the two Ernest W. Brown funds, the Isaac Roberts Fund, the Jessie Stevenson Kovalenko Fund,

and finally the Henry Norris Russell Lectureship Fund. In round figures the Life Membership Fund amounts to $5,000 while the others add up to $27,000, making a total of $32,000, which even at present day interest rates gives a substantial amount for the activities of the Society. There is no reason why we should not keep on and bring up our endowment to something like what outsiders expect of astronomers. One slight move in this direction would be to persuade more individuals to take out life memberships. The first life members got in at a bargain —only twenty-five dollars. When the rate for this privilege was placed on an actuarial basis, we understand that at least two of the former life members were so conscience-stricken that they made up the difference between what they had paid and what the current life membership would cost. The same opportunity is always open to the rest of us who feel likewise.

The Society is incorporated under the laws of the state of Illinois, with the Dearborn Observatory designated as the legal home of the Society. Several years ago when the Collector of Internal Revenue was trying to locate the Society to see about a tax on one of the bequests, the Dearborn Observatory was actually being moved two hundred yards or so on the campus at Evanston. I believe we managed to evade the collector. The Yerkes Observatory has been designated as the depository for the archives of the Society; and before this day is over, some of us should prowl around in the attic and see what the archives look like. In 1915 the Society received an official bronze medal or plaque commemorating the meeting at the San Francisco Exposition. Since that time, the medal has served as a paper weight in an office at Madison, Wisconsin; and to ease a guilty conscience, I am now turning over this plaque to the secretary with the recommendation that the Washburn Observatory be made the official keeper of all such trophies of the Society.

From the beginning, some of the main contributions of the Society to our science were through various committees. About 1920, the rule was adopted that ordinarily all committees are discharged at each annual meeting; but in the early days, a number of standing committees continued over many years. Among these may be mentioned the committees on asteroids, comets, eclipses, meteors, photographic astrometry, radial velocities, stellar parallaxes, and variable stars. The reports of these committees will be found in the *Publications*. Still continuing we have, of course, the Finance Committee and the increasingly active Teachers' Committee. One or two of the many committees appointed for special purposes bring up recollections of interesting episodes. The Committee on Variable-Star Nomenclature reported that because each of the three members was in favor of a different system of naming variable stars, little progress could be made in the work of the committee, and they asked to be discharged. There was a Committee on

Daylight Saving. President Pickering considered daylight saving merely a device to make children think they were staying up later before going to bed. I have forgotten about this committee's report, but owing to the fact that daylight saving is illegal in Wisconsin we gained one hour for this meeting today. The Committee on the Beginning of the Astronomical Day recommended the change to the beginning of the day at midnight, and this recommendation was endorsed by the Society with one dissenting vote, which vote happened to be cast by your present speaker. I am still unreconciled but I can take refuge in the Julian Day which begins then, now, and forever at Greenwich Mean Noon.

The *Publications* of the Society have had an interesting history. At first the reports of the meetings were scattered in different journals like *Science* and POPULAR ASTRONOMY, but after ten years these reports were all gathered together into Volume 1 by the secretary, William J. Hussey. From then on the reports of meetings, abstracts of papers, and the valuable reports of observatories were reprinted, largely from POPULAR ASTRONOMY, and distributed to the members and libraries. So far as I know, ours was the only organization which got out a publication at its own expense and distributed it free everywhere. After the first World War, the cost of printing increased so much that this liberal policy had to be changed; and whereas similar societies nearly became bankrupt on account of their journals, we managed to come through unscathed simply because the *Astronomical Journal* and the *Astrophysical Journal* had support from other sources. As you know, the *Publications* in their first form came to an end with Volume 10 in 1943; and since then the abstracts and reports of observatories have been published in the *Astronomical Journal*. The Society was able to take over the publication of the *Astronomical Journal* only because Dirk Brouwer was willing to serve as editor, with Louise Jenkins as assistant editor. Three associate editors are appointed by the Society, and another by the directors of the Gould Fund who have continued a substantial subsidy in support of that journal. The Society now has also a closer connection with the *Astrophysical Journal*, since the nine collaborating editors are designated by the Society. But the important connections with these journals are the reduced rates of subscription to members. Up till now there has been no compulsion about such subscriptions, but perhaps we can look forward to the time when our Society will be on the same basis as others: membership in the Society to mean subscription to a journal.

The Society has had the usual relations with similar societies, such as joint meetings, joint committees, and so on. Astronomy is now represented in the National Research Council by two members who are chosen at our annual elections. The American Section of the International Astronomical Union is officially organized under the Division of Physical Sciences of the National Research Council. The executive

committee of this Section, which serves between meetings of the Union, is composed of the president and secretary of the Society, the two members of the Division, and the American vice-president of the Union. Thus, the international relations are effectively in the hands of our national Society.

Ultimately someone will undertake to write the history of the Society during the next fifty years. By noting the tendencies in the past, we can extrapolate some predictions. The membership has certainly become younger. In the photograph of that first meeting at Yerkes, if we look at the faces of the men and the dresses of the ladies, we can see how we have changed. Probably we are now as young as we can get. The steady increase in numbers is a cause for mixed feelings. Surely when we get very much larger our best days will be behind us. The mere problem of finding a place to meet will be a serious one. We already have a number of local groups like the Midwestern Group, the Ohio-Michigan-Indiana Group, the New England Neighbors, and the larger Astronomical Society of the Pacific, not to mention the many strictly amateur societies who all have our best wishes. Our national meetings are large enough; and, to my mind, it would be bad to divide the scientific sessions into separate sections. Members of other organizations have often noted that the atmosphere around the astronomical meetings is like that of a club while that of larger societies is much like a market. We should hate to lose the intimate contacts which we get in the small Society. The friendships which one makes with his professional colleagues are the lasting ones; and let us continue as President Simon Newcomb said in his letter declining further election: "Through the Society we share the advantages enjoyed by the promoters of other branches of pure and applied science, which flow from mutual help, counsel, criticism, and friendly interest."

The present is a rather late date to discuss what our profession would be in this country without the Astronomical Society; astronomers must have been a group of lonely individuals in the eighties and nineties when they had little opportunity to get together. Those doing research were pretty far apart with few personal contacts. One thing which the Society has done has been to eliminate various controversies which otherwise might have appeared in print. I remember a case of two individuals who were at sword's points before they came to a meeting; but it was arranged for them to sit next to each other at the dinner; and at the end it was gratifying to see them shaking hands and saying how glad they were to have had the opportunity to talk things over.

I must apologize for the levity of some of my remarks. They certainly would have been out of place fifty years ago; but, as I told you, we have grown younger. What we have lost in dignity we may have gained a little in the way of a good time. For addresses appropriate to an occasion like this we can refer to those at the dedication: by

James E. Keeler on "The Importance of Astrophysical Research and the Relation of Astrophysics to other Physical Sciences;" by George E. Hale on "The Aim of the Yerkes Observatory;" and by Simon Newcomb on "Some Aspects of American Astronomy." These addresses were published in the *Astrophysical Journal* for November, 1897; they make as good reading now as when they were delivered, and they could well be required reading for astronomers fifty years hence.

The American Astronomical Society and the Yerkes Observatory are of the same age and parentage. Unlike many twins on their fiftieth anniversary, we can be proud of our lives as we have lived them thus far, and we can promise still better careers in the half century to come. In all human probability we shall be able to celebrate, again together, our first centennial with even better prospects for the future.

The Yerkes Observatory, 1897-1947*

By OTTO STRUVE

The purpose of this anniversary session is not to solicit compliments or to have a good time, though we were fortunate to receive many of the former and though we hope to get a taste of the latter—after we have attended to the strenuous business of speaking and listening. If today our organization departs from its everyday routine it is for the purpose of taking stock and appraising our accomplishments and our failures.

The Yerkes Observatory began its work in the summer of 1897. Hale, Barnard, and Burnham—the latter two being the most experienced visual observers in America and perhaps in the entire world—agreed that the optical qualities of the 40-inch objective were as fine as could be desired. They did not wait for the formal dedication of the observatory in the middle of October, but succeeded during the preceding four or five months in accumulating measures of double stars—some of them newly discovered with the great refractor—of nebulae, and star clusters.

A few days ago Miss Arville Walker, whom many of you know as the capable secretary of Professor Shapley at the Harvard Observatory, wrote me that out of sheer curiosity she had looked up Professor Pickering's letters of 1897 to see whether he had made any comments on the Yerkes dedication. There was first a letter to Mr. Hale asking whether ladies would be welcome—can you imagine today such a question?—and mentioning that he would bring Mrs. Pickering with him unless he heard from Mr. Hale that the ladies were not wanted. He also complained that Mrs. Draper—the name is familiar to you from the Draper catalogue and other great astronomical projects—had failed to receive an invitation. From the picture of the group it is evident that the ladies were victorious; they attended in considerable numbers

*Read at the fiftieth anniversary celebration on September 6, 1947.

and from the stern expression on the face of one astronomer's wife you can see that they were not prepared to tolerate any nonsense!

After Director Pickering's return to Harvard he wrote a report to President Eliot and I quote from it as follows:

"I returned from Chicago this afternoon. Our trip was a success except for the coolness at the end. No such gathering of astronomers had hitherto been held in America. The papers and discussions were unusually good and the Observatory and its equipment superb. President Harper was most friendly and introduced me at the closing banquet as representing 'Harvard University the Mother of American Colleges.' With his aid I was able to carry out (I hope successfully) the somewhat delicate operation of impressing on Mr. Yerkes the necessity of endowing his Observatory so as to provide for current expenses."

This kind and solicitous effort remained, however, without consequence. Mr. Yerkes could not or would not endow the Observatory which he had created, and to this day the entire financial support for maintenance, operation, and staff salaries has come from the regular budget of the University of Chicago.

It is clear to us now that Pickering's opinion was correct. The Yerkes Observatory was conceived as something vastly larger and more important than even a first-rank astronomy department of a large university. It was meant to provide for the Middle West what the combined resources of Harvard, Yale, and Princeton provided for the East and what Lick and later Mount Wilson provided for the West Coast.

From the very beginning its annual budget was far in excess of what a normal department of the University could expect to receive from the limited resources at the disposal of President Harper. Today its budget is of the order of close to a quarter of a million dollars per year—including the McDonald Observatory—and it probably is one of the three largest University appropriations for astronomical research. Moreover, Harvard, with its vastly superior endowment, and Lick, with a university of the size of that of California behind it, have received in the form of later gifts, if not original donations, a measure of financial support which Yerkes has never had.

Throughout the administrations of Dr. Hale and Dr. Frost the Yerkes Observatory had to struggle against the results of poverty: there was not enough money to pay adequate salaries to the staff and to attract the best research workers, nor were there adequate funds for maintaining the quality of the original equipment.

If during the past 15 years we did not have to worry quite so much over our finances, that was entirely due to two causes: the plan for cooperative research with the University of Texas, which gave us the use of the 82-inch reflector of the McDonald Observatory, and the wisdom of Chancellor Hutchins, who was not afraid to support a pure and

therefore impractical science, and in this manner to approach his ideal of the function of a true university.

These measures can give but temporary relief. An observatory which cannot freely experiment with new devices such as those of ultraviolet rocket spectroscopy, of electronics, of radio frequency receivers, not to speak of modern developments in the construction of telescopes and cameras and spectrographs is doomed to gradual stagnation. We do not now have even the minimum resources which we need to carry on our work as we think it should be carried on and we realize that even now we absorb a greater share of the university's income than is consistent with the place of astronomy in the organization. We ask the people of the Middle West to help us now in creating what Pickering thought was necessary in 1897—an adequate endowment fund for research.

The tremendous impetus which the war has given to the physical sciences is felt in astronomy as it is in physics and chemistry. While we are pouring billions into nuclear research we must not neglect the supporting science of astronomy. Let us not forget that scientists in the 1940's knew that the energy of the nucleus could be released because in the 1930's astronomers like Eddington, Atkinson, and Chandrasekhar had shown that in the stars the process of nuclear fusion produces the energies of stellar radiation, and physicists like Bethe and V. Weizsäcker accurately described the manner in which hydrogen is gradually converted into helium.

In the course of the fifteen years of my directorship I have never asked for financial support: the University took care of our needs on a scale that was adequate. Now, for the first time, I feel that I must clearly state the case: the department of astronomy cannot maintain its place in science unless there is more money for new instruments, for staff salaries and for graduate and postgraduate student fellowships.

The Observatory in the fifty years of its existence has taken an active part in the training of young and sometimes of old astronomers. During Dr. Frost's directorship it was said—perhaps with a slight exaggeration—that more than half of the country's observatory directors and departmental chairmen were his pupils or former associates. The Observatory started giving the degree of Ph.D. in 1912 and the first of a long procession of Yerkes doctors of philosophy was the present editor of Popular Astronomy, Professor C. H. Gingrich. He was followed in the next year by our Evanston host, Professor O. J. Lee. Even before that, the astronomy department in Chicago—in collaboration with the Observatory—had been awarding degrees on the campus. Professor Forest Ray Moulton, in 1900, was the first. Since that time our doctors have spread to all corners of the United States and to many foreign countries.

I remember the thrill it gave me to discover, a few days after my

arrival in Williams Bay in 1921, that the initials EPH carved into the wood of my desk drawer meant Edwin P. Hubble. At one time a considerable fraction of the personnel of the Mount Wilson Observatory had close ties with Yerkes. Hale, Adams, Ellerman, and Pease were among those who went in 1904 to Pasadena and formed the original Mt. Wilson staff. St. John, the famous observer of solar phenomena, was a research associate here in 1901-2. Joy and van Maanen, together with two other astronomers spent some time at Williams Bay. During the summer they camped out of doors in a tent. Van Maanen who was born and raised in Holland had little experience with electrical storms of the kind we often have here in summer time. When lightning struck a nearby tree, so the story goes, he became so frightened that he moved out of the tent and soon afterwards out of Williams Bay altogether in order to go to Mount Wilson and there to begin his Kapteyn-inspired work on accurate measurements of proper motions, parallaxes, etc. Edison Pettit and Edwin P. Hubble were graduate students and recipients of the Ph.D. In 1926 Walter Baade spent several months at Yerkes before going to Pasadena where he has made his home during the past 20 years. Our latest gift to Mount Wilson was our former colleague Horace W. Babcock whose recent brilliant success in determining the magnetism of stars has made headway during the past months.

At the Lick Observatory we proudly recognize W. H. Wright as our first fellow in astronomy. He was here even before the 40-inch was installed and took part in the determination of the geographical coordinates of the new observatory.

At Harvard our connection was cemented through the exchange of summer lecturers. Bok and Mrs. Gaposchkin spent the summers of 1936 and 1937, respectively, at Williams Bay, while Dr. Morgan and I have in other years both taken part in the pre-war summer school of astronomy at Harvard.

The exchange idea has not been much in use. But in one other case it worked to everybody's satisfaction. Our Society's secretary, Dr. C. M. Huffer, a good many years ago, was an exchange astronomer at Yerkes, while our Dr. C. T. Elvey took his place at Madison.

Among our closest friends and former colleagues we claim the present director of the McCormick Observatory, Dr. H. L. Alden, who was a fellow here in 1912-13; and his predecessor, Dr. S. A. Mitchell spent several years here as a member of the regular staff and as visiting astronomer. When he was first expected to arrive at Williams Bay, in 1899, Mr. Barnard hired a horse and buggy from the local livery stable and went to the station to meet him. He returned home alone to the disappointment of Mrs. Barnard who had dinner ready for the visiting astronomer from Columbia University. There was no one on the train but a young boy. Half an hour later this boy appeared at the door carrying his suitcase. You have all seen Dr. Mitchell at recent meetings

of the Society. It is hard to think of a man of his distinguished appearance as being passed by as a mere "boy."

Among other distinguished astronomers who were at one time connected with the Yerkes Observatory we remember Frank C. Jordan who took his Ph.D. degree here under Parkhurst, and later became the director of the Allegheny Observatory. Professors Leavenworth and Beal of Minnesota, Slocum of Wesleyan University, Fox and Lee of Northwestern, Stetson of the M.I.T., Miss Young, Miss Bigelow, Miss Farnsworth, and Miss Lois Slocum have all worked here.

There have been many astronomers from foreign lands. The first visiting astronomer from abroad, during the summer of 1898, was the great Russian astrophysicist, A. A. Belapolsky. Other visitors from Russia included Gerasimovic and Ogradnikoff, and more recently Shajn. Belgium was represented by Van der Linden, Bourgeois, Ledoux, Pauwen, and especially Swings.

South America was represented by Mario Schonberg from Brazil and Cesco and Sahade from Argentina. From Mexico came Señor Gallo and later Münch-Paniagua and Rivera-Terrazas.

[Following this, Dr. Struve showed on the screen, with comments, a number of early photographs of equipment and personnel.]

The Brown University-Skyscrapers Eclipse Expedition of May 20, 1947

By CHARLES H. SMILEY

For the sixth time in fifteen years, Brown University was joined by Skyscrapers, Inc., amateur astronomical society of Rhode Island, in sponsoring an expedition to observe a central solar eclipse. A party of nine persons was sent by steamer to Brazil to observe the total solar eclipse of May 20, 1947, at Araxa, Minas Gerais. Unlike some of the earlier expeditions, this one can be counted a scientific success, even though the skies were cloudy at eclipse time, for the party made more than fifteen thousand astronomical observations on the way down and back.

The members of the party were Professor Charles H. Smiley of Brown University, Director, Mrs. Charles H. Smiley, Professor Walter L. Moore of the University of Louisville, Mr. and Mrs. Donald S. Reed, Miss Mary Quirk, Miss Wilhelmina Null, Miss Miriam Jolley, and Miss Maribelle Cormack. Miss Jolley and Miss Cormack were unable to remain with the party for the return voyage and flew back to the United States; the remainder of the group made the full trip together. More than a hundred other persons expressed a desire to join

the expedition, many of them well qualified. It is hoped that some of them may be included in later eclipse expeditions.

It was originally planned to arrive in Brazil at least three weeks before eclipse day, but it was impossible to obtain space on a steamer this early, even though requests for reservations had been made as early as November, 1946. As late as March 17, 1947, the party was informed that no space would be available. Finally arrangements were made to sail on one steamer from New York on April 14; two days later this was changed to another steamer sailing on April 10. Later this was changed again to another vessel leaving on the 15th of April. Most of the group left Providence by train, while all of the equipment and most of the baggage were sent down to New York by station wagon. Professor Moore went with the equipment, and Mr. James S. O'Brien, Jr., an assistant at Ladd Observatory, served as driver, returning the station wagon to Providence after the equipment had been loaded on the ship.

The vessel was a Liberty Ship and we were to occupy the gun crew's quarters at the stern of the ship. The quarters were crowded, the ship was heavily laden with deck cargo, and a cat walk had been erected over drums of gasoline to allow one to reach amidships. Later we found that the steering gear, directly beneath us, was very noisy; the motion of the ship would lift the sternhouse up and down about twenty feet each time. It was like sleeping in an elevator running all night in a two-story boiler factory.

The ship did not sail on schedule; in fact, it left the pier in Brooklyn about midnight on the 21st of April. The following morning found it anchored not far from the Statue of Liberty! It was then we learned that the ship was not going directly to Santos as previously announced, but would put in at Trinidad for fuel. This would take about two extra days of travelling time. Later at Trinidad, the fueling operation was completed at about midnight one night, but the ship did not get under way again until the following morning. Not far from Natal, Brazil, the ship stopped its engines one night.

Despite the inconveniences and delays, the members of the party remained in good spirits. Each morning a little more than an hour before dawn, they were up on deck observing the zodiacal light. Special maps had been prepared and more than 500 copies of each printed, showing the sky 25° on either side of the plane of the ecliptic. The boundaries of the zodiacal light and a line indicating the position of the horizon were plotted on these. On comparing the sketches made by the various members of the party on the same evening, it was found that the shape of the triangles varied greatly. Mr. Reed pointed out that it has been found that persons sketching objects tend to endow those objects with their own proportions. This was found to be true of the zodiacal light

sketches; a short, fat person plotted a short, fat triangle, and a tall thin person, a tall thin triangle.

At sunrise each day, half of the party was up on the flying bridge measuring the vertical diameter of the sun. The purpose of these measures was to determine the atmospheric refraction at low angular altitudes. The work was being done in coöperation with the Office of Naval Research, United States Navy, and five excellent modern sextants, a brand new chronometer, five second-setting watches and several other pieces of equipment were provided by them for our use.

After slightly more than half an hour, our first crew would retire and the remainder of the party would take over and observe for the rest of the hour. A similar program was carried out at sunset time each day.

Our group carried an independent record of the navigation of the ship. Instead of making a single observation of each celestial body, each of our observers would make six to twelve observations of a single body, one right after another. This gave us not only an accurate position of the ship to compare with that found by the ship's navigator, but also statistical information on the reliability of the individual observers. One of the members of the crew remarked it was the first ship he had ever been on where the passengers worked harder than the ship's officers.

Not all of the time was spent in work. When the ship crossed the Tropic of Cancer, several members of the party poured bottles of waterproof black ink into the ocean to mark the line. The usual photographs were taken at the sub-solar point. After the traditional ceremonies at the equator, King Neptune was presented with a ball-point fountain pen with a guarantee from the maker that it would write under water, and a written statement from members of the party that it would *not* write above water. No especial program was arranged for the crossing the Tropic of Capricorn; too much time had been lost by then and it was doubtful whether we would be able to reach Araxa in time to set up our equipment. The captain found that he would not arrive at Santos before dark on the 13th of May; he therefore ordered the ship's speed reduced. We anchored outside Santos harbor and did not go in until well after dawn.

We were able to go ashore at noon and from that moment on we had every possible coöperation. Mr. A. G. Parsloe, American Consul at Santos and widely known as the "Mayor of Santos," told us that two automobiles and a truck were ready to transport us and all of our equipment up the Via Anchieta, the splendid mountain highway to Sao Paulo, and that a two-motor plane had been placed at our disposal through the courtesy of Sr. Amadeu da Silveira Saraiva, President of Viacao Aerea Sao Paulo (VASP Airways). This would take us from Sao Paulo to Araxa in a few hours!

We were entertained at dinner at the well-known Automobile Club in Sao Paulo by Mr. Cecil M. P. Cross, American Consul General. Early the following morning we flew to Araxa and in the afternoon we chose our observing site at an abandoned airport south of Araxa.

We stayed at the splendid new Grande Hotel at Araxa, just completed in 1946 and said by many to be even more luxurious than Quitandinha, the famous hotel at Petropolis, Brazil. There were many times in the five days before the eclipse when we wished that we could just stop and rest and enjoy the hotel and its surroundings. Only through the generous assistance of many Brazilians, and in particular, of the Brazilian Eclipse Commission headed by Dr. Benedito Quintino dos Santos, were we able to get concrete piers erected for the equatorial mount, the polar axis properly aligned, and the cameras checked for focus. Mr. Reed and Dr. Moore looked after this part of the work.

Miss Mary Quirk was in charge of the determination of the longitude and latitude of our site. Some eighty observations of altitudes of celestial bodies, well distributed in azimuth, were made with sextants and artificial horizons, and with a new Wild theodolite by members of the party. A least squares reduction of the observations resulted in an adopted position, 19° 40′.3 S, 46° 56′.8 W, with probable errors less than 0′.1. It was planned to determine the position with greater precision after the eclipse.

Our eclipse program called for photographic and visual observations of the outer corona and the zodiacal light in the neighborhood of the sun, and the photographic and visual determination of the precise times of the four contacts. Mr. and Mrs. Reed were to use the Schwarzschild camera (f/3, 36 inches focal length) and the Schmidt camera (f/1, 4 inches focal length) to photograph the outer corona and the zodiacal light in black-and-white and in color. Miss Quirk, Miss Null, and Miss Jolley were to make measures of the absolute brightness of the same phenomena with visual photometers, each with eyes well dark-adapted; Mrs. Smiley, Dr. Moore, and Miss Cormack were to record for these observers. Dr. Smiley was to carry the time count and to observe the outer corona and zodiacal light with dark-adapted eyes and to record their form and extent. Dr. Moore was to make a series of precisely timed photographs of the partial phases with a camera (f/44, 132 inches focal length) to determine the times of contact.

A high-speed motion picture camera with sound recording equipment was flown from the United States, and Captain Elwood H. Neener and Technical Sergeant Hiram Brown, both of the U. S. Army Signal Corps Photographic Center on Long Island, N. Y., set up this equipment and were to use it during the eclipse. An objective prism was used to allow the recording of the flash spectrum at second and third contact, and radio time signals were to be recorded on the sound track. The precise times of second and third contact were to be determined

by this device and were to be used in determining the linear distance from our site to one in Africa. Because electricity was not available at the old airport, these instruments were located on a balcony on the top floor of the hotel. Captain Neener and Sergeant Brown deserve especial credit for the speed and efficiency with which they set up this equipment.

Mr. C. M. P. Cross, his daughter, Jean, and Mr. Orton Hoover, also of the American Consulate General in Sao Paulo, very generously consented to assist us in our program and were assigned duties which considerably lessened the strain on the remainder of the party.

The final adjustments of the eclipse equipment were completed about 1:30 A.M. on the 20th. After a short night's sleep, the members of the party started up to the eclipse site about 4:00 A.M. At sunrise, the sky was completely overcast except for a small strip along the eastern horizon. The sun disappeared into the clouds and was not seen again until after the third contact. Then it was seen briefly two or three times before fourth contact.

No photographs were taken with the eclipse cameras; the visual photometers were used to measure the brightness of the overcast sky, hoping thereby to obtain the times of second and third contacts within a second as we had at Roblin, Manitoba, Canada, on July 9, 1945. Our results in Brazil were not as good as those in Canada.

After the eclipse, we remained at Araxa for a week, resting and packing up our equipment. On the 27th, we flew back to Sao Paulo with all of our baggage, again in a special VASP plane. On the 29th, we attended a meeting of the Brazilian Academy of Science in Rio de Janeiro at which many of the visiting astronomers spoke. We also attended a series of meetings of scientific societies of the state of Minas Gerais at Belo Horizonte on June 2-3.

It will not be possible here even to list all of the courtesies extended to us by the Brazilians. On leaving Brazil, we felt that we had made many good friends and that we knew a little better this vast and beautiful country.

We boarded the *S.S. Willis Van Devanter* of the Moore-McCormack Line at Santos on June 10 and started our homeward voyage. Although this ship and our quarters on it were supposedly identical with those on the ship going down, they were actually much superior, cleaner, less crowded and better cared for. Even more important, we had the complete coöperation of the captain and officers of the ship. Captain Richard A. Flint and his staff extended every possible courtesy to us, for which we were very grateful.

Observations in our atmospheric refraction program made on the way home brought our total to 15,000. Approximately ten percent of these measurements were of altitudes of celestial bodies, enough to navigate a modern passenger ship three or four times around the world.

The complete reduction of the 15,000 observations will probably take a year.

I should like here to acknowledge our indebtedness to the many persons who generously supported the expedition financially. Without this assistance, the expedition would have been impossible. I should like to repeat our appreciation of the friendly help of many Brazilians, Sr. Amadeu da Silveira Saraiva, Dr. Benedito Quintino dos Santos, Sr. Ricardo Gentil Montandon, Sr. Joan da Silva Monteiro Filho and others. Not least of the contributions to be acknowledged were those of the members of the party who gave up almost six weeks of their time to travel down and back on a surface vessel so that they could share in the work on atmospheric refraction. They worked hard and long, first in preparation for the trip and later in doing the work that needed to be done. To them goes my highest praise.

LADD OBSERVATORY, BROWN UNIVERSITY, PROVIDENCE, R. I., SEPT. 6, 1947.

Planetary Theories

By A. PANNEKOEK

INTRODUCTION

In the history of astronomical science the development of planetary theory takes a prominent place. The progress of astronomy from the dawn of civilization up to fairly modern times is measured by the growing knowledge of the planetary motions. Whilst the practical needs of human life could be satisfied by knowledge of the phenomena of sun and moon and the regularities found therein, it was the intricate wanderings of the five other wandering luminaries that struck the imagination, awoke a higher type of curiosity, convinced man of a deeper relationship between the life of the heavenly bodies and his own, and set his intelligence to work to solve their mysteries. If we say that the stars have first raised man to his high intellectual and scientific status, it must be added that it was the planets that lifted his mind to the study of these scientific problems.

So planetary theories were the gist of astronomy during the thousands of years of its rise. Ever again after centuries of social and cultural development, of patient observing and calculating, and of growing ideas, progress came, as by leaps and bounds, in the form of new planetary theories, opening new vistas, superseding their forerunners, reaching a higher degree of perfection. Thus the works of Ptolemy, of Copernicus, of Kepler, of Newton, of Laplace represent the consecutive steps in our knowledge of world-structure. They are the mile stones in the history of astronomy. As a condensed embodiment of the growth of his science they should be dear to every astronomer who is alive to its cultural importance.

Circumstances, however, prevent the general acquaintance with these works among modern astronomers. They have been written mostly in classic languages, Latin or Greek, unknown to modern students of natural science, and they are only partly accessible by translations. They are often lengthy, diverging in elaborate time-absorbing details that do not interest modern readers. Then there is the strong specialization needed for taking part in modern astronomical research, claiming the entire attention of the worker in this field; and the enchantment of the wonderful discoveries in the stellar world, captivating the imagination, and leaving no time and thought for penetrating into other fields. Still it must be emphazied that the study of the history of astronomy is no less important than the study of astronomy itself. It is the study of man in his upward spiritual course; and men stand nearer to us than do the stars. It may be asserted that to know the evolution of mankind, its causes and forces, to us is more important even than to know the evolution of the stars.

Hence it may not be useless, or uninteresting, to give a survey and critical discussion of the planetary theories as contained in the great classical works. Then it will appear that they are neither documents of bygone ignorance nor perfect exposures of superhuman mastership, but assiduous works from men of genius struggling in their own way with the difficult problems, solving them as far as possible at the time by their gifts of enthusiasm and perseverance, but forced to leave much in an imperfect state. In their totality they present the image of the upward course of human knowledge about the universe.

The Planetary Theory of Kidinnu

I

In the wide plains of Mesopotamia mounds are to be seen where the Arabian villagers happen to dig out clay tablets with cuneiform characters, which they sell to western collectors. Sometimes the latter find out the whereabouts of the buried remnants and expeditions are sent to dig out systematically the entire hidden lot of relics for a museum. This is preferable, because the villagers, in cleaning the objects, often brush away with the dirt part of the inscriptions; for these clay objects mostly were not hardened in fire, because, probably, they were not deemed important enough to be preserved. The inscriptions show that in olden times important cities were situated here, as Uruk, Borsippa, Sippara; they show, moreover, that the tables belonged to the archives or contents of temples.

Uruk and Sippara are among the oldest sites of Mesopotamia, mentioned already in the centuries before 2000 B.C. Afterwards they were overshadowed by and subjected to Babylon, the great commercial and cultural centre of the Oriental world, the metropolis or one of the chief capitals of the succeeding empires, the Old-Babylonian, the Assyrian,

the New-Babylonian, the Persian, and the Macedonian. Then, under the Seleucid dynasty, cut off from the new Mediterranean world commerce, its glory went down; under the Parthian dynasty of the Arsacids it is hardly mentioned any more. But the ancient secondary towns remained as local centers, where the old science and culture were preserved during some centuries, and even developed to a higher stage.

The tablets that concern us contain almost exclusively rows of numbers, without any explanation as to meaning; the additional occurrence, however, of the well-known cuneiform characters for the months and for the zodiacal signs shows that they deal with astronomical phenomena. It must be kept in mind that though we speak of tablets we usually have only broken fragments, small pieces damaged and unreadable over large parts, the result of the devastations in which the towns have perished. If the left upper border is present on the fragment, we find there as an introductory sentence: "In the name of the god Bel and the goddess Beltis my masters, an omen." This sacral formula at the start of the rows of figures shows that we are dealing with priest-science that also with an advanced state of knowledge clings to the old consecrated formulas. The tables have been made by priests, or by their pupils, as a kind of exercises or copies. At the end sometimes indications are found on the contents and about the authors of the tables.

On one of the tablets, dealing with the moon, at the end is written: "Computing table of (or after) Kidinnu, from 208 to 210, (made by) Bania (son of) Nabu-belat-su-ikbi . . . son of the priest of Bel in Sippara. . ." Here we meet with the name of a Chaldaean astronomer as the author or inventor of the method of computation applied in these tables. In another text we meet with another name, Naburiannu, as the author of the method of computation. The same names we find mentioned by later Roman authors, as Strabo and Vettius Valens; they speak of Cidenas, Naburiannos, and Sudinos as Chaldaean astronomers. The data are lacking that should enable us to derive exactly the achievements of each of them; it is assumed that Naburiannu lived in Borsippa about 300 B.C., and that Kidinnu, a century afterwards, worked at Sippara. The methods used are different, as if proceeding from different schools. Those coming from Sippara represent the highest stage of Chaldaean science, which we then may render by calling it the planetary theory of Kidinnu. Thus this first of planetary theories is not left to us in the form of a complete standard work, but only as a collection of shattered fragments and half-destroyed shards. Out of the inscribed figures meaning and contents of the theory had to be derived by a series of most painstaking and ingenious investigations.

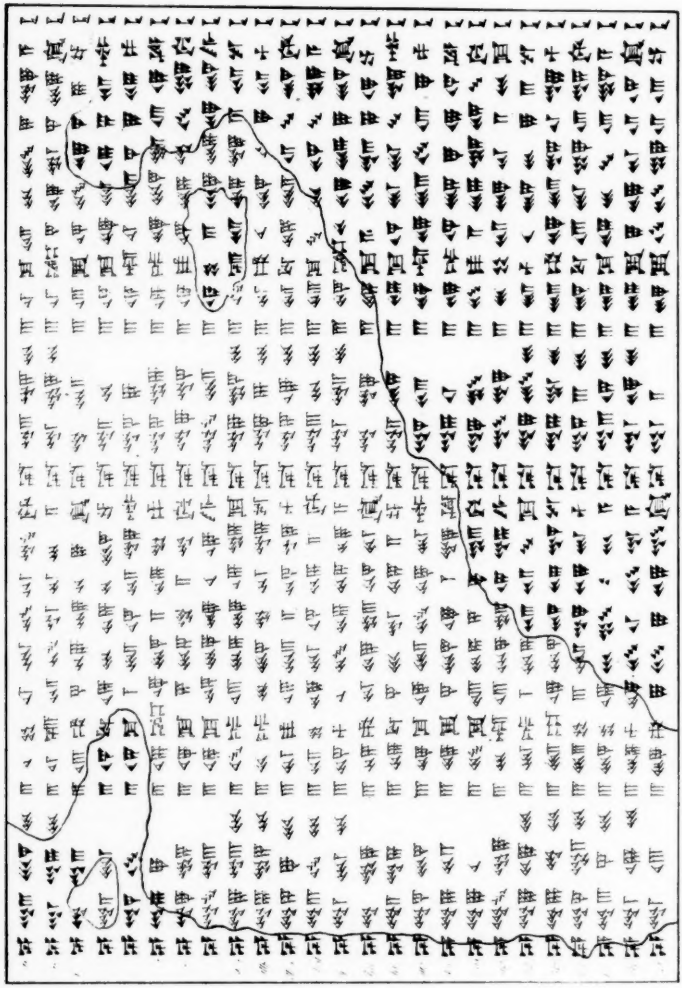
II

As a first specimen we take a fragment, denoted Sp. II 46 in the collection of the British Museum. A copy made by the able Assyriologist,

Father Strassmaier, S. J., has been printed in Kugler's great work "Sternkunde und Sterndienst in Babel, Book I. Entwicklung der Babylonischen Planetenkunde" (Development of Babylonian Planetary Knowledge) 1907; we give a reproduction on page 426. Father F. X. Kugler, S. J., was the man who with great sagacity deciphered this and many other planetary and lunar tables, and thus laid the solid foundation for our knowledge of Babylonian astronomy.

The rows of cuneiform characters consist chiefly in numbers; units are given by simple standing wedges, occurring up to the number of 9; hooks standing before them denote tens and occur up to the number of 5, so that 59 is the largest number appearing in the tables. It shows that a sexagesimal system was used; large numbers were denoted by sexagesimals (c.q. of higher order), and fractions by sixtieths, also of different orders for decreasing quantities (we denote the different orders by separating them by means of commas). Thus we are able to transcribe their numbers into our system. Between the rows of numbers we see a column with different characters, known already from other inscriptions to be the names of the Babylonian months; in our transcription denoted by the Roman figures I-XII. Often we find that after the 12th month a 13th is added. In Babylon an exact lunar calendar was in use, each month beginning with the appearance of the young sickle-moon, with full moon at the 13th or 14th, and the last disappearing sickle at the 26th or 27th of the month. Since a lunar period is 29½ days, hence 12 months count 354 days, 11¼ days short of a year, every 3rd or 2nd year a 13th month had to be inserted; in the last centuries B.C. it was done, after a fixed rule, 7 times in 19 years. Further on to the right-hand side we see a column of characters representing the 12 constellations of the zodiac, which we have rendered in our transcription by our well-known signs. The present fragment clearly consists of a left-hand half up to the column with only one identical character read "ush," and an entirely analogous right-hand half ending with the character "shu"; each consists of 6 chief groups of columns. In the reproduction the well-preserved readable parts have the cuneiform characters given in hollow outlines, whereas the missing, afterwards computed values, omitted in our transcription, are given in entirely black characters.

What is the meaning of these numbers? The second row 3 10, 3 11, 3 13, in the sexagesimal system means 190, 191, 193; they increase one for each next line, but when the month in the next column changes back from XII to I or II they make a jump of two; so they must indicate years, going from 190 to 217. From other sources where "Seleukus king" is added, we understand that they are years of the Seleucid era (S.E.) that began with the year 311 B.C., hence the table gives data holding for 121 till 94 B.C. The numbers behind the names of the months, never exceeding 30, must represent dates. Before the signs of the zodiac there are columns of two numbers, one not surpassing 30, the



Sp. II 46. Obverse Side

..	..	30	3	10	XII	11	31	29	21	49	♑	US	43	45	30	3	11	IV	22	30	39	5	47 ♌	SU
..	..	30	3	11	XIII	22	29	41	21	30	♌	"	41	57	30	3	12	V	4	28	51	4	38 ♍	"
..	..		3	13	II	4	28	38	20	8	♍	"	40	32		3	13	VI	14	29	..	..	6 ♎	"
42	31		..	..	III	16	30	26	20	34	♎	"	42	20		3	14	VII	27	..	..			
..	..		..	..	..	1	32	14	22	48	♏	"	44	8		3	15	VIII	11	..	..			
..	7		3	16	V	17	34	2	26	50	♐	"	45	56		3	16	IX	27	34	52			
47	55		3	17	VII	5	35	50	2	40	♒	"	47	44		3	17	XI	14	36	40			
49	43		3	18	VII	25	37	38	10	18	♓	"	49	32		3	..	..	..	37	36			
48	43	30	3	19	IX	13	36	38	16	56	♈	"	48	54	30	3	19	..	..	35	48			
46	55	30	3	20	IX	30	34	50	21	46	♉	"	47	6	30	3	21	II	10	34	..			
45	7	30	3	21	XI	15	33	2	24	48	♊	"	45	18	30	3	22	III	25	32	..			
43	19	30	3	22	XII	28	31	14	26	2	♋	"	43	30	30	3	23	IV	9					
41	31	30	3	24	I	10	29	26	25	28	♌	"	41	42	30	3	24							
40	58		3	25	II	21	28	53	24	21	♍	"	40	47		3	25							
42	46		3	26	III	4	30	41	25	2	♎	"	42	..										
44	34		3	27	IV	18	32	29	27	31	♏													
46	22		3	28	VI	4	34	17	1	48	♑													
48	10		3	29	VI	23	36	5																
49	58		3	30	VIII	13	37	53																
48	28	30	3	31	IX	1	36	..																
46	40	30	3	32	X	18	34	..																
44	52	30	3	33	XII	3																		
43	4	30	3	34	XIII	16																		
41	16	30	3	36	I	27																		
41	13		3	37	II	..																		

Transcription of Sp. II 46. Obverse Side

other up to 59; they give the longitude in signs, degrees, and minutes, hence in our mode of writing 111° 49′, 141° 30′, 170° 8′, etc.

The succeeding lines in the left-hand half of the table clearly represent consecutive similar phenomena indicated by the name "ush." They follow one another with an interval of one year and one month (*i.e.*, 13 lunar months) increased by 10 to 20 days. This is sufficient for an astronomer to know that we are dealing here with phenomena of the planet Jupiter; for the synodic period of Jupiter is one month longer than a solar year. Since the dates of the Seleucid era are exactly known we are able to compute from modern data what phenomena are represented here. It appears on computation of Jupiter's longitudes that the Chaldaean values are all 4°-5° too large, *i.e.*, they are reckoned from a vernal point 4°-5° back relative to the momentary vernal point of the time. Thus reduced, Jupiter's longitudes are all nearly 120° larger than the sun's; so the phenomenon denoted by "ush" must be the second stationary point where the retrograde motion turns into a direct one. In the same way the right-hand parts are found to represent the planet's heliacal setting, the disappearance in the evening. So we may infer —confirmed by other fragments—that analogous columns to the left-hand side, representing heliacal rising, first stationary point, and opposition, have been broken off. On the back side of the fragment the tables are continued for the years 218-231 S.E.

III

So the Chaldaean astronomers in the last centuries B.C. were able to construct planetary tables giving the exact date and the longitude in minutes of the prominent phenomena. How did they construct them? We first take the longitudes, for which Kugler gave a complete explanation. The succeeding longitudes show unequal intervals that are written down in the preceding column:

$$141° 30′ - 111° 49′ = 29° 41′;\ 170° 8′ - 141° 30′ = 28° 38′;$$
$$200° 34′ - 170° 8′ = 30° 26′ \ldots$$

The relative situation of the columns indicates that the value of each longitude is found by adding the interval-value to the preceding longitude.

$$111° 49′ + 29° 41′ = 141° 30′;\ 141° 30′ + 28° 38′ = 170° 8′;$$
$$170° 8′ + 30° 26′ = 200° 34′, \text{ etc.}$$

How have the values in the column of intervals been formed? They move up and down between about 28° and 38°; indeed Jupiter on the average increases its longitude by 33° in a synodic period. Writing down their differences, we find them always 1° 48′, except for the highest and for the lowest values. It makes the impression that the interval-value is running down quite regularly till it is reflected at some lowest limit, then is running upward with the same regularity till it is reflected

against an upper barrier, then resumes its downward course, and so on. The exact values of these limits can be easily ascertained: 29° 41′ — 1° 48′ = 27° 53′ would be the 3rd value if there had been no reflection; the table gives 28° 38′, hence the reflection point is midway between them: 28° 15½′. In the same way the upper limit is found from ½ (37° 38′ + 1° 48′ + 36° 38′) to be 38° 2′. In the graph all the values are situated on straight lines running up and down in zigzag between

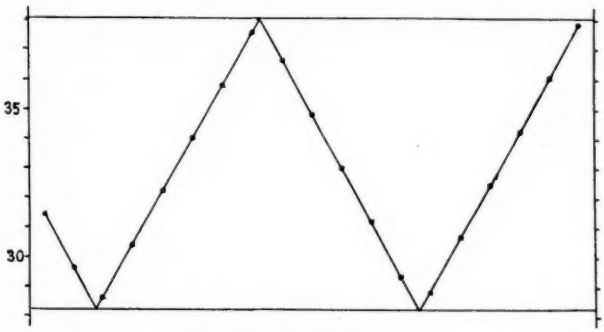


FIGURE 1
SYNODIC ARCS OF JUPITER

the limits 28° 15½′ and 38° 2′ (corresponding to longitudes of nearly 150° and 330°), at equal horizontal distances that correspond to vertical steps of 1° 48′. Now that the law of formation has been established all the missing lines on the broken off or illegible parts can be restored, and even errors in the tables, of copying or computation, can be detected and corrected in many cases. Thus it was that the longitudes themselves as well as the other columns could be computed and filled in in the reproduction.

These tables enable us to ascertain the state of knowledge of the Chaldaean astronomers on the planetary motions. The oscillation of the synodic arc above and below its mean value shows that they were acquainted with the variable velocity of Jupiter in its revolution along the ecliptic. The average value adopted for the synodic arc is the exact mean of the upper and lower limit, *viz.*, 33° 8′ 45″. The number of synodic arcs contained in the ecliptic, 360° : 33° 8¾′ = 10 1370/1591 is at the same time the ratio of the period of revolution and the synodic period. The oscillation period of the synodic arc, since it is identical with the period of revolution, must show the same ratio. Indeed we find the ratio of the double amplitude of the oscillation 2 × (38° 2′ — 28° 15½′) to the value of one step 1° 48′ to be 19° 33′ : 1° 48′ = 10 31/36. This is a simpler value of the ratio than that found above, which it approximates very nearly (31/36 × 1591 = 1370 1/36). Computing the mean synodic arc by means of the simpler ratio 36/391 ×

360° we find 33° 8′ 44″.5, which as to the degree of exactness needed here could be rounded off to 33° 8′ 45″. So there is no doubt that the authors of these tables adopted the ratio of revolution and synodic period to be 391:36. Modern elements (Leverrier) give the mean synodic arc 33° 8′ 37″.5; if, however, we take into account the great 930-year oscillation of the period, we find for the centuries between 350 and 150 B.C., a value 6″ greater. This extreme accuracy of the Chaldaean value of course for a large part is chance; in the case of other planets larger errors were present.

IV

The moments of the phenomena are given in the table to days only; but the preceding columns show that a more precise computation has been used to derive these dates. They have not been treated by Kugler; the present author first has established the structure of these columns, and then the well-known mathematician B. L. Van der Waerden has completely cleared up their derivation. That the values in the preceding columns are days and their sexagesimal fractions is shown by the fact that they nearly coincide with the intervals of the dates beside them (from the 6th line downward we find these intervals, taking account of the 13-month years, to be $2^m - 12^d$, $1^m + 20^d$, $2^m - 12^d$, $1^m + 17^d$, $2^m - 15^d$, etc.). Thus it is probable that they are the intervals used to derive each date by adding it to the preceding date.

The intervals in days run up and down in the same way as the intervals in degrees used for the longitudes; the same constant difference 1, 48 is used here, and the upper and lower limit, found to be 50, 7, 15[1] and 40, 20, 45 days, have the same numerical value of the difference: 9, 46, 30. The mean of the extremes is 45, 14 days; by this amount the synodic period of Jupiter surpasses a lunar year of 12 lunar months. We can derive the same quantity from our result on the ratio of the periods found above. The synodic period is $1 + 36/391$ solar year, *i.e.*, $365.256 + 33.628 = 398.884$ days. The lunar year contains 12×29.5306 days $= 354.367$ days. Hence Jupiter's period surpasses the lunar year by 44.517 days. The table, however, gives 45 14/60 = 45.23 days, *i.e.*, 0.71 day more. There must be something wrong here.

The problems posed by time and date are more complicated than those of longitude because here time reckoning and calendar come into play. The firm basis of the Babylonian calendar was the month, the moon's period, always beginning with the evening appearance of the moon's crescent. The relation between month and solar year was well known and, in these later centuries, followed a fixed rule; so there never could exist any doubt as to the number of months, in the past and in future. But for the relation between month and day there was no established rule. Whereas the mean duration of a month was nearly 29½ days,

[1] The commas separate the sexagesimal fractions of different order.

and months of 29 and of 30 days alternated in some way, there did not exist a fixed rule for their alternation. Only by a continuous record of the length of every month the number of elapsed days could be ascertained; and for future times this was impossible. Hence in predictions, in tables of future phenomena no exact date could be given.

From this embarrassment the Chaldaean astronomers have saved themselves by making use of months only and leaving out the real days entirely. For practical reasons they divided the month into 30 equal parts (which we may denote as moon-days), each 29.5306/30 times the ordinary day. Thus there was no difficulty in predicting future phenomena at exact dates. These dates, surely, could deviate fractions of days from the real dates; but for such planetary phenomena as oppositions or heliacal risings or settings it did no harm, and for stationary points still less. Expressed in these moon-days the excess of Jupiter's synodic period over a lunar year was $44.517 \times 30/29.5306 = 45.23$, exactly the value used in the tables. So there is no doubt about the formation of the interval columns and their use to derive the given dates, under omission of the sexagesimal fractions.

In the left-hand table, for the 2nd stationary points, the intervals for the dates are all 12, 5, 30 or 12, 5, 0 larger than for the longitudes; both run parallel up and down, having practically the same points of reflection against the upper and lower limit. In the right-hand table, for the heliacal settings, this does not hold; in the decreasing part the former are 13, 6, 30 larger, in the ascending part 11, 4, 0 larger than the latter (average 12, 5, 15 as in the other table); there is a notable displacement of phase in the points of reflection. This is due to the fact that not only Jupiter but also the sun has a variable velocity along the ecliptic. That the irregularity of the sun's motion was well known to the Chaldaean astronomers is shown clearly by their lunar tables. In the relative positions of Jupiter and the sun, their oppositions, conjunctions, and other phenomena, the combined effect of the irregularities of both luminaries must present itself. But in a different way. Since Jupiter moves slowly, 1/12° per day, and the sun moves 12 times more rapidly, the place of their meeting will hardly be influenced by solar irregularities but is almost entirely dependent on Jupiter; whereas the time of their meeting reflects the sun's advancing or retarding to its full amount. At 250° longitude the sun's velocity is largest, about 1/30 above the mean; per month it gains nearly a day, and by so much the meetings or conjunctions with Jupiter come earlier. This longitude corresponds to the midst of the decreasing row of intervals; hence here the time intervals must be one day smaller than on the average. We are speaking of the conjunctions here; the phenomena of heliacal rising and setting deviate from the conjunctions only 10° in longitude, so the same may be said to hold for them. The right-hand table of heliacal settings, indeed, gives the intervals in the decreasing row 1, 1, 15 =

1 1/48 day smaller than the average, and in the increasing row the same amount larger. So there can be no doubt that these differences are introduced to take account of the variable velocity of the sun.

This implies that for the oppositions, when the counterpoint of the sun meets with the planet, just the reverse must hold. We cannot make a control, because we do not have at our disposal any table of oppositions of Jupiter of this kind. In the second stationary point Jupiter's longitude surpasses the sun's by 120° ; hence the extremes of solar velocity correspond to longitudes 10° and 190° of Jupiter. These are so much nearer to the reflection points of the zigzag graph that the effect must be greatly weakened in the time intervals. Thus it may be understood that in the left-hand table of date intervals no essential difference with the longitude intervals between the ascending and the descending branches is perceptible.

V

What the empirical data of observation on which this theory is based are we do not know; we can only conjecture with more or less probability how the tables have been derived. We know from other texts that during many earlier centuries the positions of the planets relative to the stars were observed; and since the 6th century B.C., as numerical data, in degrees. Though we do not know what instrument they used, the Babylonian astronomers must have been able by some kind of measurement to ascertain the longitudes in degrees and fractions. The most salient phenomena for accurate measurement were the stationary points; their advance with each succeeding period provided reliable data for the synodic arc. It must not have been difficult to ascertain that at one side of the zodiac, in the Virgin, it was nearly 30° and at the opposite side, in the Fishes, it was 36°. This state of knowledge we find attested in a more primitive kind of Jupiter-tables (called, by Kugler, tables of the 1st kind), of which a number of fragments are known from between 134 and 218 S.E. Here the synodic arc is simply assumed to be 30° in one-half, 36° in the other half of the ecliptic; of course the halves must be unequal, stretching 205° for the large, 155° for the small value, in order to have the mean value exactly equal to 33° 8′ 45″. With this kind of reckoning the errors in the resulting longitudes of course are greater, up to several degrees. An attempt to diminish them may be seen in the so-called tables of the 2nd kind, where between the ecliptical realms with 36° and 30° regions are interposed in which an intermediate value 33° 45′ is assumed. Belonging to this mode of treatment an instruction-text has been preserved with prescriptions how the tables have to be computed; it reveals at the same time how those astronomers considered the planet's course. There it is said that in the slow part of the ecliptic Jupiter from heliacal rising to the first stationary point proceeds 16° 15′, then till opposition retreats 4°, after opposition performs 4° 20′ to the second stationary point, and then pro-

ceeds 15° 50′ to heliacal setting. In the part of the ecliptic with most rapid motion all these values have to be increased by ⅕, in the parts with intermediate velocity by ⅛. We may consider it as highly probable that these tables represent earlier states of knowledge, out of which the theoretical treatment has developed which we ascribe to Kidinnu. Whether one of the former stages must be ascribed to Naburiannu we do not know.

The accurate value of the mean motion in Babylonian astronomy presupposes a long period of regular observation. Once the priest-astrologers looked regularly after the planets it was not difficult for them to perceive that after 11 periods, *i.e.*, 12 years, Jupiter had performed 4½° more than a complete revolution, which gives a synodic arc of 33° 8′. After 6 such revolutions with one period subtracted, in 65 periods = 71 years, Jupiter has performed 5½° less than 6 full circles. Still more accurately it returns to the same place after one revolution more, in 76 periods = 83 years, with a deviation of 1° only. Both periods, of 71 and of 83 years, are often used in the later centuries to predict the positions of Jupiter by copying, with the necessary corrections, the observed records of 71 or 83 years earlier. If observations extending over some more of these periods were available, a still narrower concordance could be obtained by adding one synodic period to 6 times the 71-year period, or by adding one revolution to 5 times the 83-year period. Then we get a 427-year period, comprising 391 synodic periods or 36 revolutions of Jupiter, only by a small fraction of a degree surpassing 36 times 360°. To reach this degree of perfection, the Chaldaean tables needed, and probably had the disposal over, many centuries of observations.

VI

For the other planets the fragments available of their tables are far more scarce. Two pieces from 155-167 S.E. dealing unmistakably with Saturn show the same structure as the tables of Jupiter, a row of synodic arcs regularly increasing and decreasing by 0° 12′ and indicating one point of reflection at 14° 4′ 42½″. The other limit is lacking; since, however, the ratio of the periods appears in two data, in the mean synodic arc and in the amplitude of the zigzag movement, it could be computed by Van der Waerden to be 11° 14′ 2½″ [½ (14, 4, 42½ + x) : 360 = 0, 12 : 2 × (14, 4, 42½ — x)]. The resulting mean synodic arc 12° 39′ 22½″ deviates from the true value 12° 38′ 46″ considerably more than in the case of Jupiter.

A tablet from Uruk dealing with Mars shows synodic arcs constant for every two signs of the zodiac: for 30°-90°, 90°-150°, etc., having the values 45°, 30°, 40°, 60°, 90°, 67½°. The structure corresponds to the primitive kind of Jupiter's tables, but, owing to the strongly variable velocity of Mars, in a more detailed way. From these data the mean value of the synodic arc is found to be 6 × 60° : (4/3 + 2 + 3/2 +

$1 + 2/3 + 8/9) = 48° 43' 19''$ (true value $48° 42' 44''$), corresponding to a ratio 151 synodic periods = 133 revolutions.

Some fragments of a large tablet contain appearance, stationary point, and disappearance, first in the evening sky, then in the morning, of the planet Venus. Since 5 synodic periods of Venus are almost equal to 8 years, nearly the same longitudes, only $2° 40'$ or $2° 30'$ smaller, and the same dates, only 4 days earlier, return after every 5 lines. Then the synodic arc comes out to be $575° 28'$ or $30'$ (true value $575° 31' 5''$) corresponding to a synodic period of 583.9 days. Five such periods indeed are 4 days less than 99 lunar months. More cannot be derived from the scanty materials.

Among the tablets treated by Kugler, fragments of tables of Mercury also are found. Mercury offered in all later times a hard problem to the astronomers. In trying to understand what the Babylonian astronomers knew to make out of it, we are at the disadvantage that explications or prescriptions are lacking; we have only the result, the tables themselves, incomplete and often with copying errors. So we have to follow the inverse way, to derive from our modern knowledge what characteristics the early astronomers must have remarked in the phenomena that interested them. These phenomena were the alternating appearance and disappearance of the planet in the evening and in the morning sky; what they aimed at was to derive consecutive series of these phenomena, their date and longitude, by adding intervals after a certain rule. The dates in the consecutive lines follow one another with 4 months interval, corresponding to Mercury's mean synodic period of 116 days, and the mean synodic arc is 114°. Irregularities in these intervals arise not only from the irregularities of its own motion but also from the variable conditions of visibility. In the morning in October (and the evening in March) the ecliptic is nearly perpendicular, in the morning in April (and the evening in September) is inclined 30°-40° to the horizon. The distance from the sun at which the planet is just visible at the horizon, right above the sun is much smaller than in the second case, and may be estimated at about 8° in one, 16° in the other case. Assuming these values we can compute for a regular series of times and longitudes of Mercury the variable values of distance, elongation, velocity, and conjunction, and derive the synodic arc between two consecutive analogous phenomena as a function of the longitude of its starting point. As could be expected we find a continuous regular yearly oscillation; for the morning appearances (Eastern heliacal rising) for which the tables are most nearly complete, the graph of the synodic arc is represented in Figure 2; it varies between a maximum of 133° at longitude about 320° and a minimum of 93° at about 160°.

Only the tables for the morning phenomena in the years 170-185 S.E. (141-126 B.C.) were sufficiently legible and complete to derive their structure. The synodic arcs used as intervals to find the successive

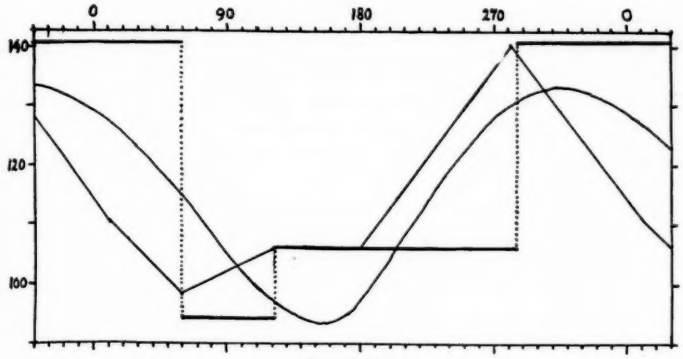


FIGURE 2
SYNODIC ARCS OF MERCURY

longitudes are less regular than we met with for the other planets: from 121° to 180° as starting point they are constant 106°; then till longitude 282⅓° they increase gradually, 20′ per degree, up to 140°, whereupon till $\lambda = 10°\ 10'$ they decrease at the same rate, and till 60° at the rate of 15′ per degree, till a minimum of 98° is reached; then an increase of ⅛° per degree leads back to the value 106°. They are represented by the broken line in the graph. This complicated arrangement is partly apparent only; the underlying theoretical conception is that the ecliptic is divided into three areas, each with a constant value of the synodic arc: from longitude 121° to 286° (*i.e.*, over 165°) it is 106°; from 286° to 60° (*i.e.*, over 134°) it is $4/3 \times 106° = 141⅓°$, and from 60° to 121° (*i.e.*, over 61°) it is $8/9 \times 106° = 94\ 2/9°$. Only because the real synodic arc mostly extends over two of these areas (or even three) it shows in the practical computation gradually increasing and decreasing values.

In both forms this structure shows a deviation from the curve resulting from our approximate computation. It shows a marked asymmetry (condensed in the situation of the small area of lowest value 94°), for which we cannot find any reason in the planet's motion; it must be remembered that with Mars also we had an asymmetry between the accelerating and the retarding parts of its revolution. Moreover the low values extend from longitude 10° to 190° instead of being situated around 160°; and the maximum occurs at 280° instead of 320°. This divergence corresponds to what Kugler found in comparing the Chaldaean longitudes with the values computed from modern data. Generally there was concordance within one or two degrees, but in the longitudes 330°-10° the Chaldaean values were about 10° too large, a difference decreasing rapidly in the adjacent regions toward 290° and 90°. Such an error must make the synodic arcs starting at, say, between 180° and 270° too large, and those starting at about 300° to 30° too

small, in accordance with the differences shown on the graph. So it is probable that the data, observations in the unfavorable spring time, on which the theory was based here, were considerably in error. Considering that the heliacal risings always take place in strong twilight when there are no bright stars visible in the immediate vicinity to compare with, we cannot be surprised if large errors occurred sometimes in the observations.

For the morning disappearances the Chaldaean astronomers have not used an analogous method of computation; they have chosen a shorter way, by simply adding to the data of appearance values representing the period of visibility as a morning star and the corresponding increase of longitude. These values depend on the greatest elongation, and they moreover are larger when, owing to the steepness of the ecliptic, the planet is visible at a smaller elongation. The latter case holds for October, and so we find in the tables that the amount added to the longitude of appearance oscillates between a maximum of 44°, holding for $\lambda = 210°\text{-}270°$ (autumn) and a minimum of 12°, holding for $\lambda = 0°$ to 30° (spring).

If we consider that up to the beginning of the 17th century the tables gave errors sometimes reaching 7° in the longitudes of Mercury, it is highly remarkable that the Oriental priest-astronomers with their scanty means succeeded in so well representing at least the main phenomena of this difficult and irregular planet. Still more than for the single places this holds for the periods; here, probably, they had at their disposal data extending over some centuries. From the values and the extent of the different synodic arcs we find for their number in the entire circumference of the ecliptic $(165 + 3/4 \times 134 + 9/8 \times 61) : 106 = 2673 : 848$; hence one synodic arc = 114° 12′ 31″.5, which against the true value 114° 12′ 35″.6 computed from modern data shows a difference of 0.001 percent only, making an error of 1° in 300 years. In accuracy it surpasses Ptolemy's later value.

VII

In the planetary tables preserved in cuneiform inscriptions from Mesopotamia we are confronted with a theory of the planetary motions, entirely different in structure from the ancient Greek and the modern astronomical theories. The latter in their essence are geometrical theories; they are based upon the assumption of orbits in space, described by the planets, first of circular motions, afterwards refined to eccentric circles and ellipses. The periodical irregularities in the motions find their adequate expression in the wave-curve, the sine-function. Chaldaean theory, on the contrary, is purely algebraic; it does not proceed from any orbit in space but consists in simple operations with numbers, continually repeated additions of equal numerical values. The periodical character of the phenomena, which in the first primitive theories is obtained by abruptly alternating larger and smaller constant

values, after the more refined method attributed to Kidinnu is realized by reflection and reversal of regularly increasing or decreasing differences against fixed limiting values. What precision can be reached in this way?

In the straight part between two reflections the intervals form an arithmetic series proceeding with constant differences; adding them we get an arithmetic series of the second order; its graphical representation is a parabola. The graph of the periodical deviations from a constant course consists of a series of parabolic tops, turned alternately upward and downward, replacing the two halves of the sine-curve of modern theory. That the difference is not large may be deduced from an imagined simple example, where the result of six differences increasing with steps of 1° 4′ and reflected at ±3° 12′ is compared with a sine function with amplitude 5°:

intervals	+2° 40′	+1° 36′	+0° 32′	−0° 32′	−1° 36′	−2° 40	−2° 40′	−1° 36′
results	0°	+2° 40′	+4° 16′	+4° 48′	+4° 16′	+2° 40′	0°	−2° 40′ . .
sine function	0°	+2° 30′	+4° 20′	+5° 0′	+4° 20′	+2° 30′	0°	−2° 30′ . .
Differences	0°	+10°	−4′	−12′	−4′	+10′	0°	−10′ +4′

Since the mean error of Babylonian measures has been estimated at ½°, the differences remain far below that estimate. It is true that Kugler found larger errors in the longitudes of the Jupiter tables, after the correction for the difference of 4° 36′ in the adopted vernal point going up to more than 1½°. But they are due to the Chaldaean astronomers having assumed a too large amplitude of 9¾° between the limits; a value of 7°-8° would have fitted better.

As a theoretical system of planetary motions, to represent the observed positions of the past and to predict positions for the future, the Chaldaean algebraic method is quite as practicable as the geometrical method of Greek astronomy. In accurate knowledge of periods it even surpassed contemporary Greek science. But it could not give a regular fluent course of velocities; it was bound to abrupt changes and jumps in the successive values. It remains restricted completely to a rendering of apparent motions by means of numerical computations, without any image of spatial positions and real motions. For the Chaldaean astronomers the planets remained, manifestly, up to the last centuries, divine luminaries roaming along the heavenly vault, proceeding and returning, in pendulations and loops; orbits in space are never heard of, save occasionally as an echo of rumors of Greek origin.

What may be the cause of this peculiar character of Chaldaean science? Doubtless it is due to the fact that from its origin it was a priest-science, and remained so till the end, through the powerful tradition of the temples as intellectual centers. Whereas in Greece, by the geographical and political division into small units, the priests remained local functionaries, in the large empires of the Orient a strongly centralized powerful clerical hierarchy could arise that held intellectual

leadership in its hands. In such a society the traditions of olden times keep their power over the minds. When science is entirely the business of a caste of priests, for whom pure conservation of the old worship is the basis of life and thought, independent new ideas on the world and its structure cannot come forth. In these conditions probably we have to look for the cause of the practically highly developed and at the same time theoretically primitive character of the Chaldaean planetary theory. Babylonian science was a science of priests, Greek science was a science of laymen.

The Planets in November, 1947

By RAYMOND H. WILSON, JR.

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. During this period the sun sinks rapidly southward to within 2 degrees of its lowest winter position at the end of the month. An annular eclipse will be visible as partial over all the United States except the Lake Region, on the afternoon of November 12.

Moon. The phases of the moon will occur as follows:

		d	h	
Last Quarter	November	5	11	A.M.
New Moon		12	2	P.M.
First Quarter		20	4	P.M.
Full Moon		28	3	A.M.

Perigee occurs on November 3 and 30.

No bright stars will be occulted.

Evening and Morning Stars. Jupiter may still be visible shortly after sunset at the beginning of the month. Near it will be the brighter Venus, which will become an increasingly conspicuous evening star. Mars and Saturn will be a brilliant pair in the morning sky; also Mercury will be a morning star during the last part of this month.

Mercury. On November 22 Mercury reaches a position 20 degrees west of the sun. Therefore, it may be visible in the east just before sunrise for a few days around that date.

Venus. By its moving eastward faster than the sun Venus will become more easily visible in the southwestern twilight. It will set an hour after the sun at the end of the month. On November 9 it will be only a degree south of Jupiter, and on November 14 a few degrees west of the moon.

Mars. The red planet will be easily found just west of the star Regulus in the morning sky, rising at about midnight in the middle of the month. On November 11 it will overtake Saturn, passing less than a degree to the north.

Jupiter. About the last visible phenomenon of this synodic period will be a

close conjunction with Venus on November 9; after this, Jupiter will be lost in the encroaching twilight.

Saturn. When it reaches 90 degrees west of the sun, in the middle of the month, Saturn will rise at midnight, being just west of the constellation Leo. A close conjunction with Mars on November 11 will be an outstanding configuration.

Uranus. Uranus will be moving slowly westward, about 4 degrees northwest of ζ Tauri.

Neptune. Neptune will be moving southeastward, in an area 3 degrees south of γ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
September 2, 1947.

Asteroid Notes

By HUGH S. RICE

4 asteroids of note are visible in small telescopes this autumn and early winter, and we have been observing all but one, the latter not being ready yet, since its ephemeris does not begin until November.

PALLAS is in Aquarius, a little southwest of Alpha Aquarii in mid-October. It passed the opposition point in late August and will be at its stationary point in late October. At the beginning of October its photo-magnitude is given as 10.1. This corresponds to approximately 8.7 visual magnitude, as based on former observations. We picked it up in mid-September, north of Alpha Aquarii, when its visual magnitude was supposed to be about 8.5, but it appears to be about 0.3 magnitude fainter. PALLAS is not difficult to locate, and is following its track precisely, as well as can be determined in the Zeiss 50 mm glass.

CERES, the giant among the minor planets, is in evidence again, fortunately, and is making another *apparition.* [We feel it is not good to let this old word apparition die out. There seems to be a tendency for it to become obsolescent, but it is an excellent word in this applied meaning.] For our first observation at this apparition of CERES, we picked up the planet from indoors with the window closed, and located it instantaneously upon peering into the glass; moreover the identification was positive. What better can one do? This can only be accomplished under certain conditions. The conditions were not ideal, in that the sky was typical of New York skies: it was not possible quite to discern the entire head of the Whale with the unaided eye. But other conditions were more ideal. Most of the work in locating asteroids is done before one goes to the telescope. We plotted the exact apparent path on a large chart. Now if at a given moment the object is close to a bright star, on the chart, one knows where to expect it, and the presence of the bright star allows the stunt-observation to become possible. In our case CERES was very near Gamma Ceti and its position on the chart was memorized before going to the telescope. It appears to be exactly in place, its position being as predicted. The predicted visual magnitude was about 8.4 and our observing notes read an estimated 8.3. CERES will be good for observation until the end of the year, and in November Alpha Piscium is a good key star with which to start.

IRIS is also under observation, and will last for some months. There is a difference between its brightness and that of CERES. IRIS attains a greater brightness but it achieves this more rapidly and diminishes more rapidly. As pointed out by Dr. Brouwer, this minor planet is of special interest, being very near perihelion at its opposition, November 7. An investigation of the orbital elements confirms the point. During the first week in November the photo-magnitude is predicted as 7.7. Past observation shows the equivalent visual magnitude to be about 6.9. In mid-September it should be about 8.1. Our observations have shown it running more than half a magnitude fainter, but it appears to be in the computed place. It was considerably more difficult to pick up—the first time—than CERES or PALLAS, because it is too far from a bright star. We went from the Pleiades to IRIS, but Zeta Arietis is better, and succeeding trials greatly shorten the time of location.

From November to early spring VESTA will make another apparition, starting in Cancer. The subjoined ephemerides are from those furnished by the Yale U. Observatory, one extrapolation being ours.

ASTEROID EPHEMERIDES
For 0^h U.T. Equinox 1947.0

2 PALLAS

1947		α h m	δ ° ′
Oct.	7	21 54.4	— 2 16
	12	21 53.3	— 3 12
	17	21 52.6	— 4 4
	22	21 52.5	— 4 52
	27	21 53.0	— 5 36
Nov.	1	21 54.5	— 6 16

1 CERES

1947		α h m	δ ° ′
Oct.	12	2 28.3	+ 1 26
	17	2 24.3	+ 1 9
	22	2 20.0	+ 0 54
	27	2 15.6	+ 0 41
Nov.	1	2 11.0	+ 0 30
	6	2 6.6	+ 0 22
	11	2 2.3	+ 0 18
	16	1 58.4	+ 0 18

7 IRIS

1947		α h m	δ ° ′
Oct.	12	3 3.3	+25 34
	17	3 1.5	+25 21
	22	2 58.8	+25 1
	27	2 55.5	+24 35
Nov.	1	2 51.6	+24 2
	6	2 47.5	+23 24
	11	2 43.4	+22 42
	16	2 39.5	+21 57

Hayden Planetarium, American Museum of Natural History,
New York, N. Y., September 20, 1947.

Occultation Predictions for November, 1947

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phe-

nomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Date 1947	Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
	Occultations Visible in Longitude +72° 30′, Latitude +42° 30′									
Nov. 1	67 Taur	5.4	1 55.1	−0.6	+1.2	93	2 49.9	−0.2	+2.2	220
1	κ Taur	4.4	1 55.3	−0.3	+1.6	72	2 56.3	−0.5	+1.8	240
1	284 B.Taur	6.0	7 59.0	−1.7	+0.2	72	9 15.7	−1.4	−1.6	260
2	118 Taur	5.9	3 1.5	−0.7	+1.0	100	3 56.9	−0.3	+2.3	225
2	BD+25°879	6.3	6 55.3	−1.1	+3.4	29	7 47.3	−2.2	−2.3	308
2	125 Taur	5.0	8 24.6	−1.8	+0.5	71	9 40.9	−1.5	−1.1	277
4	*c* Gemi	5.4	6 18.6	−0.5	+3.2	44	7 6.5	−1.8	−1.4	320
18	40 B.Capr	6.2	20 45.8	−2.4	0.0	110	21 57.7	−1.3	+1.0	214
20	35 Capr	6.0	0 9.1	−1.4	−0.2	66	1 26.6	−0.7	−0.3	236
24	14 Ceti	5.9	3 28.3	0.0	+2.9	0	4 12.7	−1.9	−2.5	287
	Occultations Visible in Longitude +91° 0′, Latitude +40° 0′									
Nov. 1	67 Taur	5.4	1 48.4	+0.1	+1.4	75	2 42.5	0.0	+1.7	241
1	κ Taur	4.4	1 51.4	+0.3	+1.6	56	2 44.7	−0.3	+1.4	260
1	284 B.Taur	6.0	7 24.0	−1.7	+1.2	65	8 44.3	−1.9	+0.3	255
2	118 Taur	5.9	2 53.2	+0.1	+1.3	81	3 48.2	−0.1	+1.6	246
2	BD+25°879	6.3	6 36.9	..	..	3	7 3.7	−3.5	−3.8	323
2	125 Taur	5.0	7 48.9	−1.6	+1.3	68	9 8.4	−2.0	0.0	268
4	*c* Gemi	5.4	6 11.8	..	..	22	6 36.0	−2.1	−2.7	337
19	35 Capr	6.0	23 39.8	−1.6	+1.1	42	1 3.4	−2.0	−0.4	260
25	μ Pisc	5.1	7 30.4	−0.8	−1.3	89	8 27.7	−0.3	+0.6	216
	Occultations Visible in Longitude +120° 0′, Latitude +36° 0′									
Nov. 1	284 B.Taur	6.0	6 45.8	−0.2	+2.6	31	7 44.0	−2.0	+0.4	280
2	125 Taur	5.0	7 12.9	−0.2	+0.5	39	8 10.2	−1.8	+0.3	286
4	4 Canc	6.2	14 20.0	−2.0	−0.7	95	15 34.6	−1.0	−1.9	302
8	ν Virg	4.2	13 48.2	..	..	57	14 17.3	..	..	10
25	μ Pisc	5.1	6 51.2	−1.9	0.0	73	8 4.7	−1.0	+1.1	216
	Occultations Visible in Longitude +98° 0′, Latitude +30° 0′*									
Nov. 1	67 Taur	5.4	1 38.3	+0.3	+0.9	86	2 27.1	+0.3	+1.6	230
1	κ Taur	4.4	1 39.4	+0.4	+1.2	66	2 30.9	+0.1	+1.3	250
1	284 B.Taur	6.0	7 0.5	−2.2	+0.7	86	8 18.6	−1.8	+2.0	227
1	95 Taur	6.2	11 30.8	−2.0	+2.5	30	12 15.8	−0.5	−3.4	314
2	118 Taur	5.9	2 43.7	+0.2	+0.8	93	3 32.8	+0.3	+1.6	234
2	BD+25°879	6.3	6 0.4	−0.2	+2.7	34	6 57.3	−2.2	−0.1	289
2	125 Taur	5.0	7 26.4	−2.0	+0.6	92	8 45.0	−2.0	+1.8	237
4	*c* Gemi	5.4	5 46.2	+0.4	+2.0	53	6 35.2	−1.0	−0.1	302
19	35 Capr	6.0	23 12.9	−2.3	+1.5	51	0 48.6	−2.4	+0.3	251
24	14 Ceti	5.9	2 56.4	..	..	331	3 16.4	..	..	304

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The return of the Perseid meteors this August was far from a spectacular one yet certain conclusions may be drawn from data now in my hands though the radiants, derivable on some of the maps, must be worked up later.

Had I depended upon my own experience, based on what the party accompanying me on the night of Aug. 11/12 saw, one could conclude that the maximum was wretchedly poor. However, the sky at our station, which was on top of the 180-foot square tower of the Bryn Athyn Cathedral, was never clear except near the zenith, most of the time nothing short of a fireball could be seen below altitude 25° to 35°, and haze passed over the rest of the sky at intervals. Hence the extensive program arranged with the aid of Mrs. R. M. Cole, professor of astronomy at Bryn Athyn College, by which a group of her students joined in the work, was pretty well ruined. The point in stressing this unprofitable experience is to emphasize that meteors cannot be properly observed or even seen unless you have a really clear sky. Indeed, had it not been the night of the Perseid maximum we would not have largely wasted our time by trying. To make meteor work worth while one must get away from artificial lights and have a clear sky, without appreciable moonlight. Any haze, fog, or excess illumination cuts down the rates terribly. This is why I now hesitate to try to get persons to join the A.M.S. who must observe from cities or even from large towns, and who cannot get out into the country. It is only fair to be frank and tell them how awfully handicapped they are unless they find means to get to a favorable place while observing. In no field of astronomy is this fact so important as with meteors; telescopic work is by no means so handicapped.

Returning to the Perseids. As reports from a distance arrived it was seen that the rates were by no means bad for those who had fine observing conditions. Among others, the Joliet Astronomical Society, reporting through our experienced member Frank Preucil, had good rates for the first half of the night. At Dubuque, Iowa, N. P. Klaas and his brother both secured rates up to the average. The Milwaukee Astronomical Society, reporting through E. A. Halbach, also had average good fortune on both Aug. 11 and 12, especially when moonlight is allowed for. In Oregon, Miss A. K. Jenson of Silverton sent in the outstanding individual report, covering six nights. Her records carry out the above remarks about rates. Others could be quoted but a study of the data in the table will show the facts.

The shower, however, did not seem to furnish many meteors of fireball class nor has anyone reported a train which lasted as long as half a minute. One we saw at Bryn Athyn doubtless would have in a clear sky. This came at 11:18 E.S.T., was a Perseid, green in color, magnitude —3, and the train was visible 10 seconds even through the haze. Several persons sent in negative reports, or of one or two casually observed meteors, or of a single fireball. These are not mentioned by name. The total number of meteors recorded in the table is 4481. Where they were plotted it will be possible, with some study, to determine quite accurately which are Perseids and which sporadic, but this has not in general been

done yet. But in some cases, largely where counts only were made, such information is available as the observers noted to which group each meteor belonged. Some examples are quoted:

Observer	Date	Perseids	Sporadic	Total
Griffeth, Miss. J.	11	22	6	28
Joliet Astr. Soc.	11	213	61	274
Preucil, F.	12	20	4	24
Federer, Mrs. H. S.	10	43	10	53
Milwaukee Astr. Soc.	11	199	34	233
Milwaukee Astr. Soc.	12	191	21	212
		688	136	824

If these are a fair sample for the three nights, Aug. 10, 11, and 12, we find for the Perseids 83%, for sporadic meteors 17%, or roughly five to one. Meteors of outstanding interest may be mentioned later, and some reports will be further analyzed. Evidently more and more women are taking an active interest as the percentage of reports by them for this August is large. We welcome their very valuable assistance.

It seems quite unreasonable to become pessimistic about future returns of the Perseids. It is certain that some parts of their orbit have a greater density than others; that crossed in 1947 happened to be one of the sparsely filled portions. That such irregularities occur is an added reason for keeping the stream under close annual scrutiny. The cylinder cut out by the Earth is such a very small part of one percent of the volume of space occupied by the steam that the number of meteors annually lost by collision with us is quite negligible compared to the whole. Hence unless the stream is undergoing steady dispersal, for which there seems no adequate cause, there should be equally strong displays for the indefinite future. That of only two years ago was, for instance, outstanding in its richness.

As to showers for the rest of 1947, the dense parts of the Leonid stream are so near aphelion that few can be expected for the next ten or more years. The Bielids, as a stream, seem utterly dispersed. Of course, on Oct. 8 and 9 watch should be kept in the slim hope that, as we pass near the orbit of Giacobini-Zinner's Comet, some of those meteors might be seen. The Orionids, Oct. 17 to at least Oct. 26, are quite regular, also the Geminids which usually come to a sharper maximum on Dec. 12/13. These latter two streams deserve the closest annual attention and all A.M.S. members are asked to observe them on as many nights as practicable.

The table needs few remarks. When data are left out of a given column it is because they were lacking in the original. Unfortunately, some omitted to say whether they used standard or daylight time. Others omitted F; in many cases I determined F as given in the table when there were notes to guide me. The rates are uncorrected; to secure corrected rates divide by F. When F is below 0.5, it is my opinion that the correction is very uncertain and such rates should not be used statistically. In the last column: C means the meteors were counted, D described in (some) detail, P that they were plotted. We do not work out rates when two or more persons report together; our unit is *the number seen per hour by one person.* It is difficult to make observers understand that each person should count wholly independently of anyone else: it makes no difference to him whether

his meteor is also seen by a dozen others, he—and each of the others—should include it in his count to secure correct individual rates.

Observer and Time	Date 1947	Began	Ended	Min.	Met.	Fac.	R	Ob.	C
Alabama									
Nauvoo—C.S.T.									
Scott, H. T.	Aug. 11	7:35	9:10	95	17	0.9	11	1	CD
Scott, T.	7	8:50	10:30	90	19	0.7	13	1	P
" "	9	9:00	12:00	180	21	0.8	7	1	P
" "	11	8:55	13:30	275	80	0.8	17	1	P
" "	12	12:20	15:20	180	91	0.8	30	1	P
" "	13	9:50	11:50	120	29	0.6	14	1	P
" "	14	9:15	11:30	130	20	0.9	9	1	P
California									
Coronado									
von Klecke, E. S.	11		15:30		16	0.2	..	2	C
Camarillo									
Striegel, Mrs. D. C.	11	10:30	13:00	140	105	...	..	?	C
" "	12	8:00	16:30	205	118	0.9	..	?	C
" "	13	8:00	13:45	230	188	...	..	?	C
" "	14	8:15	13:30	85	87	...	..	?	C
Fall Brook									
Forsyth, E. L.	11	8:31	16:15	464	63	0.9	8	1	D
" "	12	7:30	8:47	87	0	0.9	0	1	
" "	12	8:47	11:15	148	19	0.9	8	1	D
Fresno									
Bostick, Dr. J. B.	11	11:35	12:15	40	17	...	26	2	C
" "	12	9:49	10:49	60	36	...	36	2	C
" "	13	10:35	11:35	60	20	...	20	2	C
" "	14	9:03	10:03	60	21	...	21	1	C
Colorado									
Denver—M.S.T.									
Stewart, Miss P. L.	12	11:10	11:30	20	14	...	42	1	C
Connecticut									
Torrington									
Hewett, Mrs. V.	12	13:00	14:30	90	9	...	6	1	C
Florida									
Sarasota—E.S.T.									
Griffeth, Miss J.	11	12:45	14:52	127	28	0.5	23	1	P
Illinois									
Batavia—C.S.T.									
Siekman, Wm.	8	8:15	12:15	240	41	0.8	10	1	P
" "	9	9:00	14:00	300	38	0.5	8	1	P
" "	11	11:00	13:00	120	46	0.6	23	1	P
Chicago—C.S.T.									
Anderer, J.	11	13:00	15:00	120	56	0.8	28	1	C
Geneva—C.S.T.									
Schmidt, LeR.	9	9:30	13:30	180	17	0.6	6	1	D
Joliet—C.S.T.									
Preucil, W.	11	8:00	10:00	120	29	1.0	14	1	C
Price, R. L.	11	8:00	11:30	180	43	1.0	14	1	C
Price, R.	11	8:00	11:30	180	57	1.0	28	1	C
Rehnquist, E.	11	8:00	10:00	120	20	1.0	10	1	C
Cervine, F.	11	9:00	10:00	60	19	1.0	19	1	C
Knowlton, L.	11	9:00	11:30	120	50	1.0	25	1	C
Jordan, M.	11	10:30	11:30	60	26	1.0	26	1	C
Price, M.	11	10:30	11:30	60	13	1.0	13	1	C
Wilson, B. H.	11	9:00	10:00	60	17	1.0	17	1	C
Preucil, F.	12	9:45	10:45	60	24	1.0	24	1	C

Observer and Time	Date 1947	Began	Ended	Min.	Met.	Fac.	R	Ob.	C
Illinois									
Peoria—C.S.T.									
Nangle, J. E.	Aug. 11	9:15	9:45	30	8	...	16	1	C
" "		12:15	13:15	60	37	...	37	1	C
" "		13:15	14:15	60	16	...	16	1	C
" "	12	8:30	9:30	60	14	...	14	1	C
Indiana									
Elkhart—E.S.T.									
Swihart, T.	8	9:50	11:50	120	13	0.9	6	1	P
" "	9	10:20	12:20	120	16	0.9	8	1	P
" "	10	10:10	12:40	150	18	1.0	7	1	P
Plevna—C.S.T.									
Wright, M. G.	10	13:00	14:34	94	19	0.6	12	1	PC
" "	11	11:52	13:20	88	36	0.8	25	1	PC
Iowa									
Dubuque—C.S.T.									
Klass, N. P.	12	11:05	12:05	60	49	1.0	49	1	C
Klass, P.	12	11:05	12:05	60	53	1.0	53	1	C
Rippey									
Roberts, Miss C. L.	11	8:30	9:30	60	19	...	19	1	C
Roberts, Miss C. H.	11	8:30	9:30	60	12	...	12	1	C
Maine									
Bar Harbor—E.S.T.									
Lambert, Miss P. C.	10	10:40	11:30	50	4	0.9	5	1	C
" "	11	11:45	12:30	45	1	0.4	..	1	C
Seal Harbor—E.S.T.									
Turnbull, H. S.	12	7:40	9:40	120	12	...	6	1	P
" "	10	10:10	10:50	40	4	1.0	6	1	P
Sebago									
Machamer, Miss N.	12	11:00	12:00	60	9	...	9	1	C
" "	13	.....	.....	90	8	...	6	1	C
Massachusetts									
Brockton—E.S.T.									
Skinner, G. B.	11	8:00	10:55	144	16	0.7	7	1	P
" "		8:24	9:50	86	1	0.3	..	1	P
Marblehead—E.S.T.									
Knowles, J.	11	13:00	15:00	120	72	0.9	36	1	C
" "	12	13:00	15:00	120	41	0.9	20	1	C
" "	13	13:00	15:00	120	20	0.9	10	1	C
" "	14	13:00	15:00	120	21	0.9	10	1	C
Williamstown—E.S.T.									
Walker, G. B.	11	10:00	12:00	120	31	...	16	1	C
" "	12	10:30	12:30	120	32	...	16	1	C
Michigan									
Adrian									
Slater, B. H.	13	11:00	12:00	60	8	0.8	8	1	C
Nebraska									
Beatrice—C.S.T.									
Mains, M. M.	8	10:30	11:30	60	11	...	11	1	C
" "	9	12:30	13:30	60	20	...	20	1	C
" "	11	9:00	9:15	15	2	0.5	..	1	C
" "	12	9:15	11:15	120	67	...	34	1	C
Kearney									
Keenan, Miss B.	11	10:00	11:00	60	17	1.0	17	1	C
Lincoln									
Hartman, Miss G. C.	11	11:00	12:30	90	85	...	..	3	C
Omaha—C.S.T.									
Davis, R. J.	8	10:00	11:00	60	7	0.6	7	1	PD
" "	9	10:00	11:00	60	14	0.8	14	1	PD

Observer and Time	Date 1947	Began	Ended	Min.	Met.	Fac.	R	Ob.	C
Nebraska									
Crescent—C.S.T.									
Davis, R. J.	Aug. 10	9:00	11:10	130	17	1.0	8	1	PD
" "	11	8:40	11:09	149	15	1.0	6	1	PD
New Hampshire									
Danbury—E.S.T.									
Federer, Mrs. H. S.	10	9:00	13:15	240	53	0.6	13	1	C
Federer, T.	10	12:15	13:15	60	22	0.4	22	1	C
New York									
Sarasota Springs									
Kennedy, Miss M. C.	10	11:50	12:50	60	3	0.4	3	1	D
" "	11	11:50	12:50	60	9	0.4	9	1	D
" "	12	11:50	12:50	60	14	0.4	14	1	D
Spring Valley—E.S.T.									
Burns, H. A.	11	9:18	13:18	240	34	0.4	8	1	P
Ohio									
Cincinnati—E.S.T.									
Snyder, F. H.	11	9:50	11:00	70	16	0.7	14	1	C
Cleveland									
Black, J. L.	12	10:15	11:15	60	3	0.3	..	1	D
Park, R. E.	9	10:00	11:30	90	0	0.9	0	1	
" "	10	10:00	12:00	120	0	0.5	0	1	
" "	11	10:00	11:30	90	0	0.1	0	1	
" "	12	10:15	12:45	120	17	1.0	8	1	P
Oregon									
Portland—P.S.T.									
Widner, Dale	12	10:45	12:15	90	88	0.7	59	2	C
" "	13	9:00	10:00	60	41	0.7	41	2	C
Eugene—P.S.T.									
Thompson, Mrs. H.	10	15:15	15:45	30	7	0.6	14	1	C
Thompson, Miss B. J.	10	15:15	15:45	30	10	0.6	20	1	C
Thompson, Mrs. H.	11	15:15	15:45	30	16	0.6	32	1	C
Thompson, Miss B. J.	11	15:15	15:45	30	19	0.6	38	1	C
Pruett, J. H.	12	8:45	9:05	20	10	0.6	30	1	C
" "	12	14:45	15:45	60	27	0.6	27	1	C
Thompson, Mrs. H.	12	14:45	15:45	60	22	0.6	22	1	C
Thompson, Miss B. J.	12	14:45	15:45	60	25	0.6	25	1	C
Silverton—P.S.T.									
Jenson, Miss A. K.	10	11:55	12:55	60	33	1.0	33	1	C
" "	10	12:55	13:25	30	19	0.5	38	1	C
" "	11	14:03	16:03	120	94	0.5	47	1	C
" "	12	9:50	10:20	30	18	1.0	36	1	C
" "		13:03	15:32	150	122	0.5	49	1	C
" "	13	9:56	10:26	30	13	1.0	26	1	C
" "		13:07	15:37	150	92	0.8	37	1	C
" "	14	13:07	15:37	150	103	0.9	41	1	C
" "	16	13:05	15:35	150	63	1.0	25	1	C
Pennsylvania									
Bryn Athyn—E.S.T.									
Olivier, C. P.	11	10:15	12:25	130	13	0.2	..	1	PD
Cole, Mrs. R. M.	11	10:15	12:25	130	9	0.2	..	1	C
Dandridge, D.	11	10:45	12:25	130	15	0.2	..	1	C
Williamson, Miss M. L.	11	10:15	12:20	125	8	0.2	..	1	D
Others	11				8		..		C
North Hills—E.S.T.									
Shutts, R. V.	10	10:30	11:40	70	4	0.5	3	1	P
Liss, A.	10	10:30	11:40	70	10	0.5	9	1	D
Wallingford—E.S.T.									
Burns, E. H.	11	9:45	13:45	240	65	0.6	16	1	D
" "	12	8:12	10:02	110	14	0.5	..	2	D

Observer and Time	Date 1947	Began	Ended	Min.	Met.	Fac.	R	Ob.	C
Puerto Rico									
Mayaguez—E.S.T.									
Velez, A.	Aug. 12	10:30	11:30	69	19	...	19	1	c
" "		[10	12+]	...	16	...	..	1	c
South Dakota									
Dell Rapids									
Long, Mrs. B.	9	10:20	11:20	60	6	...	6	1	c
" "	10	11:15	12:15	60	9	...	9	1	c
" "	11	9:00	?	?	14	...	..	1	c
" "	13	11:15	13:00	135	15	...	7	1	c
2 others	11?			?	32	...	..	2	c
Texas									
Hamilton									
Thompson, Miss G.	12	10:00	11:00	60	12	0.5	12	1	c
Virginia									
Limeton—E.S.T.									
Mussaens, A.	11	11:00	12:30	90	9	...	6	1	c
Washington									
Clear Lake									
Minglin, Miss M. K.	11	14:20	15:20	60	33	0.4	33	1	D
Port Angeles									
Nailor, Miss N.	11	9:30	10:30	60	22	...	22	1	c
Whitbey Island									
Macdrudd, D.	10	12:30	13:00	30	10	...	20	1	c
" "	12	10:00	11:00	60	17	...	17	1	c
Wisconsin									
Wisconsin Dells—C.S.T.									
Gibson	12	9:00	16:00	420	285	0.6	41	1	c
Milwaukee									
Milwaukee Astr. Soc.									
Albrecht, W. B.	11	11:45	15:00	195	148	0.8	46	1	c
Halbach, E. A.	11	13:42	15:14	88	43	0.7	29	1	c
Lee, R. R.	11	11:42	14:14	92	42	0.9	28	1	c
Halbach, Mrs. Jane	12	13:00	15:02	122	53	0.8	26	1	c
Halbach, E. A.	12	13:21	15:21	107	56	0.8	31	1	c
Lee, R. R.	12	13:05	14:14	69	39	0.9	34	1	c
Schur, L.	12	13:05	15:00	115	64	0.8	33	1	c
Wyoming									
Laramie									
Beetle, Mrs.	10	14:05	14:45	40	12	0.5	18	1	c
" "	11	14:00	14:40	40	27	0.5	40	1	c

Flower Observatory, Upper Darby, Pa., 1947 August 30.

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)

Edited by FREDERICK C. LEONARD

Department of Astronomy, University of California, Los Angeles 24

The Orbit of the Paragould, Arkansas, Meteor*

HARRY E. NELSON *and* WARREN J. THOMSEN

Department of Mathematics & Astronomy, State University of Iowa, Iowa City

Communicated by C. C. Wylie

ABSTRACT

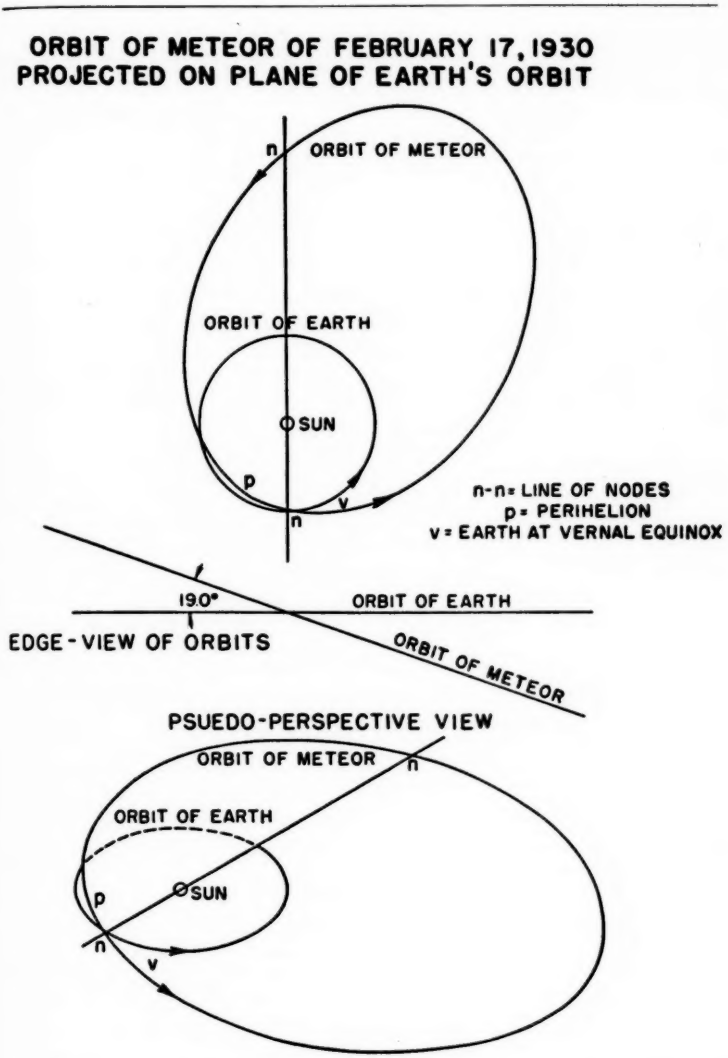
The elements of the orbit of the body that dropped the Paragould, Arkansas, meteorites of 1930 February 17 are given. The elements were calculated from the data computed in 1941 by J. F. Foster and R. L. Duncombe for the ground point, which also are included in the paper as part of the summary of the calculation of the orbit.

The Paragould meteor fell on 1930 February 17, at 4:08 A.M., C.S.T., near Paragould, Greene County, in northeastern Arkansas. This meteor dropped 3 known meteorites, one being an 800-pound stone, the largest meteorite ever recovered for which the time of fall is known and also the largest stone meteorite known, not broken by the impact of fall. Dr. C. C. Wylie of the State University of Iowa, within a month after the time of the fall, interviewed persons in Missouri, Arkansas, and Tennessee who saw the meteor. The observers in those States were asked to stand exactly where they were when the meteor was seen, and the angles of the apparent path, as recalled, were measured. The durations were obtained by timing re-enactments of actions at the time of the fall. Dr. Wylie obtained valuable data also from a local civil engineer, who had interviewed several persons in the vicinity of Paragould immediately after the fall. From these fundamental data, the apparent radiant and velocity were computed in 1941 by J. F. Foster, with R. L. Duncombe as check computer, both being graduate students at the State University of Iowa. Using this path thru the atmosphere, we have computed the heliocentric orbit of the meteor, employing formulas taken from "The Calculation of Meteor Orbits," by C. C. Wylie, *Contribution No. 9, The University of Iowa Observatory*, pp. 304-16, 1940; *P. A.*, **47**, 425-30, 478-80, 549-52, 1939.

Following is a summary of the calculation of the orbit, the notation used being the standard notation employed in orbit work. The fundamental data, obtained as just described, should be as good as those available for any meteor dropping meteorites, but the apparent radiant and velocity can have at most, perhaps, only 3-figure accuracy. In order that the internal checks might be of use, however, the calculation was carried thru to 5 significant figures. The elements of the resulting orbit are given to 4 significant figures.

*Read at the 10th Meeting of the Society, San Diego, California, 1947 June 18-19.

[The term *meteor* is used by the authors of this paper in the sense (1) of a meteorite traveling on an orbit in space and (2) of an incandescent falling meteorite in the Earth's atmosphere.—ED.]



Some points of interest are that the altitude of the apparent radiant and the apparent velocity were both found to be low. A flat path and low velocity would be expected for the meteor that dropped the largest stone recorded that was not broken at the time of fall.

The orbit is direct, and of moderate inclination and eccentricity, similar to those previously calculated at Iowa.

	Data for Ground Point	
λ	Longitude	W. 90° 46′
ϕ	Latitude	N. 35° 54′
T	1930 February 17, 4:08 A.M., C.S.T.	
h_0	Altitude radiant	13° 43′
A_0	Azimuth radiant	218° 0′
w	Apparent velocity	11.9 mi./sec.
δ_0	Apparent declination	+ 49° 23′ 24″
t_0	Apparent hour-angle	— 113° 14′ 15″
	Correction for Diurnal Aberration	
$\Delta\delta$	Declination correction	47′ 0″
$\Delta\alpha$	Right-ascension correction	40′ 50″
δ_{01}	Apparent decl. corrected	+ 50° 10′ 24″
t_{01}	Apparent hour-angle corrected	— 113° 55′ 5″
h_{01}	Altitude radiant corrected	13° 53′ 8″
A_{01}	Azimuth radiant corrected	217° 5′ 30″
	Correction for Zenith Attraction	
u	Geocentric velocity	9.6783 mi./sec.
$M = (w-u)/(w+u)$		0.10296
Δz	Zenith correction	9° 13′ 1″
	Coördinates of Geocentric Radiant	
h_2		4° 40′ 7″
A_2		217° 5′ 30″
t_2		— 123° 39′ 31″
δ_2		+ 43° 46′ 2″
α_2		331° 33′ 10″
	Apex of Earth's Motion	
δ_1		— 19° 34′ 27″
α_1		235° 3′ 41″
	Heliocentric Coördinates of Earth	
$x = -X$		— 0.83848 astron. unit
$y = -Y$		0.47998 astron. unit
$z = -Z$		0.20819 astron. unit
$r = r$		0.98831 astron. unit
$V_1 =$	Velocity of Earth	18.713 mi./sec.
	Components of Heliocentric Motion of Earth	
$V_{x1} = V_1 \cos\alpha_1 \cos\delta_1$		— 10.098 mi./sec.
$V_{y1} = V_1 \sin\alpha_1 \cos\delta_1$		— 14.454 mi./sec.
$V_{z1} = V_1 \sin\delta_1$		— 6.2694 mi./sec.
	Components of Geocentric Motion of Meteor	
$V_{x2} = -u \cos\alpha_2 \cos\delta_2$		— 6.1453 mi./sec.
$V_{y2} = -u \sin\alpha_2 \cos\delta_2$		+ 3.3294 mi./sec.
$V_{z2} = -u \sin\delta_2$		— 6.6948 mi./sec.
	Components of Heliocentric Motion of Meteor	
$V_x = V_{x1} + V_{x2}$		— 16.243 mi./sec.
$V_y = V_{y1} + V_{y2}$		— 11.124 mi./sec.
$V_z = V_{z1} + V_{z2}$		— 12.964 mi./sec.
	Heliocentric Radiant and Velocity of Meteor	
δ	Declination	+ 34° 24′ 23″
α	Right ascension	33° 21′ 55″
V	Velocity	23.572 mi./sec.
	Elements of Orbit	
a		2.504 astron. units
e		0.6347
ω		143° 58′
Ω		328° 2′
i		19° 2′.5
P		3.963 yrs.

1947 May

The Research Program of the Meteor Section of the Meteoritical Society*

C. C. Wylie, *Director of the Section*
Department of Mathematics & Astronomy, State University of Iowa, Iowa City

ABSTRACT AND INTRODUCTION

The research program of the recently established Meteor Section of the Meteoritical Society is discussed under the following 4 headings: *(a)* photographic work on shooting stars; *(b)* visual work on shooting stars; *(c)* radar observations on shooting stars; and *(d)* shadow-casting and detonating meteors. Several recommendations for future work are made.

A. *Photographic Work on Shooting Stars.*—Good work on shooting stars is being carried on by Whipple of Harvard, who has first-class equipment and is obtaining even larger cameras. From this work, the best results for the resistance of the air to meteors at the speed of luminosity, the temperature and density of the upper air, and the orbits of the meteors about the Sun are obtained.

B. *Visual Work on Shooting Stars.*—This work is being carried on primarily by Olivier of Pennsylvania and those coöperating with him. The times of maximum for shower meteors, the frequency of these meteors at maximum, the radiants, and the motion of the radiants can be determined. Predictions of the times of maximum, the frequency, and the position of the radiants should be made for the more important showers. The orbit about the Sun can be calculated from the radiant and the velocity. Formulas for calculating the radiant of associated meteors from the elements of a comet orbit have been worked out and should be published.

The relation of group to solo counts in meteor work should be determined more accurately. More simultaneous observations should be made with the naked eye and with binoculars to check the formulas for reducing telescopic estimates of magnitudes of meteors to equivalent naked-eye magnitudes. Finally, improved figures for the daily numbers of meteors of various magnitudes should be obtained.

C. *Radar Observations on Shooting Stars.*—Our British friends have succeeded in determining velocities for some 20 meteors from radar observations. For some, the deceleration due to the resistance of the air was observable. We should work on this new method of observing meteors.

D. *Shadow-Casting and Detonating Meteors.*—These meteors, the only ones that come thru the atmosphere and reach the ground as anything other than dust, should give us the most complete and accurate information on several points, but we cannot hope to have enough photographic and radar equipment to observe any appreciable number of them. For the present, it is recommended that each regional director of the Section arrange for prompt notification by the press whenever a meteor attracting attention in several States falls in his territory. From these first reports, supplemented by additional information obtained by the press at his request, and by some reports obtained directly by long-distance telephone, if necessary, the regional director should calculate a preliminary path thru the atmosphere. Workers should then be sent to key points to interview

*Read at the 10th Meeting.

observers, within 48 hours of the time of fall, if possible. At that time, interest in the meteor is still high, and the recollection of what happened when the meteor fell is still reasonably accurate in the minds of observers.

The data at the key points, including the angles for appearance and disappearance, for slope of path, and for length of path should be obtained from re-enactions, with each observer standing exactly where he was when the meteor fell. The durations of the various time-intervals, such as the duration of the light of the meteor, the interval from the light of the meteor to the detonations, the interval from the detonations to hearing the thud of a meteorite's striking should be obtained by timing a re-enactment of the actions at the time of the fall of the meteor. The intervals from detonations to the thud of the meteorite's striking are very different for large and small meteorites falling from the same meteor. In the past, this method has been used very little, only enough to show its possibilities. No provision is made for releasing the average astronomer or geologist from his teaching duties, or for paying his expenses in traveling, and he can hardly afford the time or the money to do a good job on a meteor. There are, however, approximate paths, based on reports received by letter, for several hundred of these spectacular meteors. These give much valuable information, but for many questions we need the more accurate data obtained by personal interview. It is hoped that arrangements for this work can be made soon.

1947 June 16

A Photographic Study of the Perseid Meteor Shower* (Abstract)

FRED L. WHIPPLE
Harvard College Observatory, Cambridge, Massachusetts

An outline is presented of the current program of analysis of the Harvard collection of meteor trails, for the determination of shower radiants, motions of the radiants, cosmic spreads of the radiants, and related data. The general objectives of the study are outlined. Well over 1,000 meteor trails are available for study.

The Perseid shower has been analyzed from 49 single trails and 9 doubly photographed trails observed in the interval from July 25 to August 17. The maximum activity of the photographic shower occurs on August 12. Some evidence for both an early radiant and a late radiant, with differing daily motions, is not confirmed by the least-squares analysis. The daily motion of the combined radiant is 41′ nearly due eastward, a rate intermediate with respect to the corresponding rates for the Taurid and Geminid showers.

The cosmic spread of a projected single meteor trail from the mean predicted radiant at the instant is $\pm 43'$ (p.e.). The cosmic spread from the mean Perseid radiant is much larger (more than twice) than from the Taurid or the Geminid radiant. The significance of this result is not clear as yet.

About three-quarters of the northern-station photographic meteors in the interval from August 2 to August 22 are found to belong to the Perseid shower.

President of the Society: ARTHUR S. KING, Mount Wilson Observatory, Pasadena 4, California
Secretary of the Society: OSCAR E. MONNIG, 1010 Morningside Drive, Fort Worth 3, Texas

*Read at the 10th Meeting.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Current Graphs of Special Variables: It is always of interest, to observers at least, to see in graphical form their observations of irregular variables. Included in this category are, among others, the R Coronae Borealis type variables, R Scuti, and the recurrent novae. The accompanying figure illustrates the light variations of six of these stars during the years 1946 and 1947.

Except for the first fifty days' observations of T Coronae Borealis, for which daily means are plotted, the points represent five-day means. It is to be noted that for R and T Coronae Borealis and R Scuti observations were obtained on almost every day, except when the star was in conjunction with the sun. A double minimum of R Coronae Borealis is noted early in 1946, and a wide, rather deep, minimum late in 1946 and well into 1947. For the past four months the star has been at nearly constant maximum brightness, around sixth magnitude.

S Apodis behaved more erratically than usual, finally dropping rapidly to a deep minimum, fainter than magnitude 15, in January, 1947. The star had not become visible again as late as June of this year.

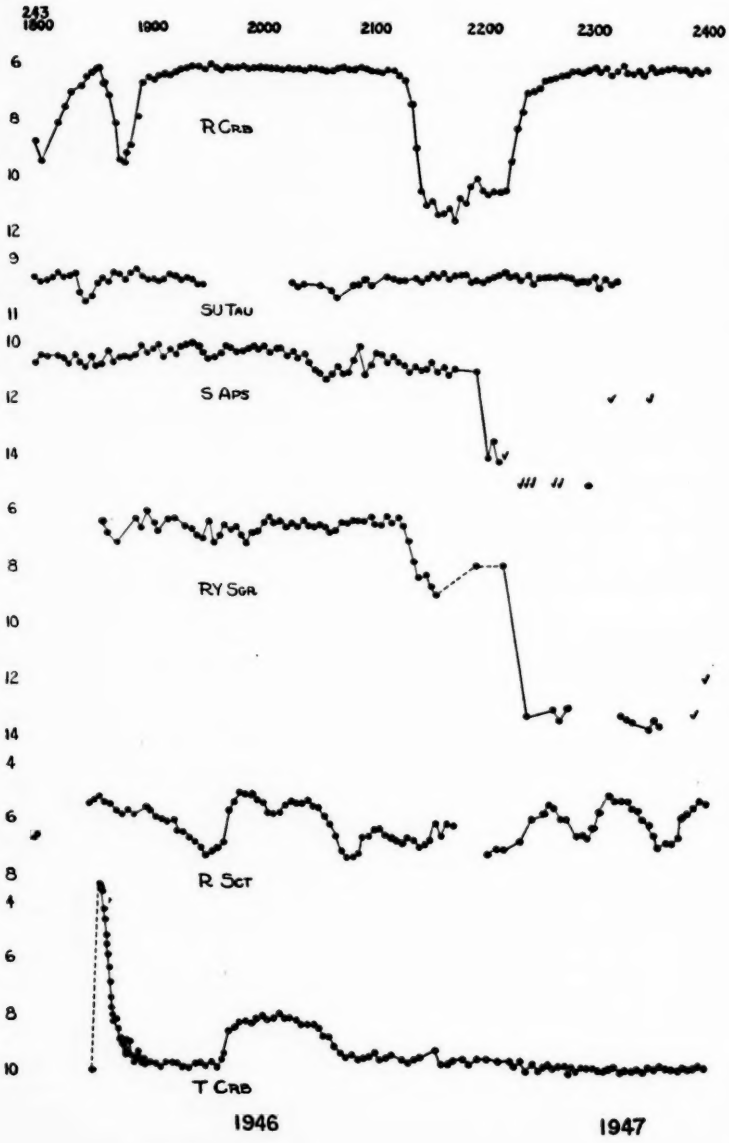
RY Sagittarii also varied in an irregular manner, fading in erratic stages to magnitude 13.5; beginning in November, 1946, and still faint in August, 1947.

Curiously enough, three of the four R Coronae Borealis-type variables regularly observed by the A.A.V.S.O. were at their faint stages at the same time. Such a feature has been noted on previous occasions, although the coincidence must be considered as accidental.

R Scuti, always an interesting, moderately-bright variable, held fairly close to its mean single term period of 71 days, but with radical differences in form of light curve in the successive periods.

The 1946-47 light curve of T Coronae Borealis follows with remarkable fidelity the outburst of 1866, not only at the bright maximum, but also at the secondary maximum. The star seems now to have reached its normal minimum stage. It has been pointed out by Pettit and others that a comparison of the visual and photographic light curves of the recent outburst indicates that the color index gradually increased as the star became fainter—the star growing redder—until the difference in color attained a value of nearly a magnitude in March, 1946. Since then the two curves have been approximately parallel, showing a constant color index. At minimum brightness the spectrum of the M-companion was clearly visible beneath the nova spectrum.

On May 6, 1946, Dr. Kukarkin of the U.S.S.R. reported the receipt of a letter from an observer at Shimanovsky, near Khabarovsh, Far East, dated February 9, which stated that the nova had been observed on February 8, 19 hours (U.T.), at magnitude 1.7. To date there has been no confirmation of this observation. If valid, it would indicate that the 1946 outburst reached the maximum brightness of the 1866 outburst.


243
1800
1900
2000
2100
2200
2300
2400
6
8
10
12
R CRB
9
11
SU TAU
10
12
14
S APS
6
8
10
12
14
RY SGR
4
6
8
R SCT
4
6
8
10
T CRB
1946
1947

Observations received during July and August: A total of 9266 observations —3967 in July and 5299 in August—were contributed by 62 and 65 observers respectively, as follows:

Observer	July—1947—August No. Var.	No. Ests.	No. Var.	No. Ests.
Ahnert	34	242	34	353
Albrecht	9	9	11	11
Alder	4	4	2	2
Ancarani	..	..	25	107
Ball	9	9	..	..
Bappu, M. K.	14	23	..	..
Bappu, M. K. V.	37	130	..	..
Bicknell	10	38	12	72
Blunck	17	23	19	26
Bogard	24	57	17	21
Boone	16	16	6	6
Brennan	3	3	3	3
Buckstaff	14	34	11	30
Canfield	..	..	5	12
Caraioryis	8	16	6	11
Chassapis	95	336	111	692
Cilley	..	..	18	50
Coleman	2	15	..	..
Cousins	..	..	21	46
Cragg	34	38	50	68
Daley	4	4	7	14
Elias	9	9	..	..
Estremadoyro	2	8	2	2
Farnsworth	3	5	..	..
Fernald	248	508	237	554
Focas	12	21	39	56
Ford	6	6	..	..
Garneau	31	32	17	17
Gingerich	12	20	..	..
Greenley	20	52	22	60
Halbach	45	54	4	4
Harris	6	6	5	5
Hartmann	102	104	105	110
Hiett	..	..	7	18
Howarth	14	15	..	..
Kotsis	..	..	23	109
Kearons	..	..	28	28
Kelly	..	..	8	8
Kilby	7	14	2	2
Kirchhoff	..	..	7	102
Kitley	..	..	27	36
Knott	..	..	27	36
de Kock	98	514	94	441
Koons	53	82	..	..
Krumm	..	..	15	39
Ledbetter	30	33	39	55
Luft	1	6	4	17
Mallas	..	..	25	79
Marrison	8	10	..	..
Miller	..	..	24	25
Nadeau	77	101	79	107
Oheim	..	..	24	26
Oravec	54	202	55	64
Paletsakis	22	338	15	385
Parks	18	18	26	44
Pearcy	31	37	43	51
Peltier	113	237	161	299
Penhallow	..	..	3	11
Petzold	14	404	11	212
Plybon	..	..	5	15
Raphael	11	50	43	215
Reeves	1	2	2	3
Renner	50	50	46	46
Rosebrugh	18	94	9	128
Sandage	16	16	12	12
Schoenke	6	8	2	4
Schroeder	30	61	..	..
Sherman	..	..	33	74
Slemaker	15	15	..	..
Stahr	8	11	..	..
Swaelen	4	4	..	..
Tarbell	..	..	5	31
Thomas	2	2	31	69
Tifft	..	..	8	8
Upjohn	15	16	20	28
Wade	7	20	10	15
Webb	20	20	17	20
Weber	31	31	30	30
Welker	21	25	16	16
Welles	6	11	..	..
Whitmarsh	8	12	6	9
Totals		3967		5299

September 15, 1947.

Comet Notes

By G. VAN BIESBROECK

The expected short-period COMET ENCKE was detected at the Lick Observatory by H. M. Jeffers on August 14. He described it as a diffuse object as faint as an 18th magnitude star. It had a coma some 2′ in diameter and centrally condensed. The measured position was only 12′ away from Matkiewicz's prediction

and showed that perihelion will occur on November 26.16 Universal Time. The following corrected ephemeris by L. E. Cunningham (*H.C.O. Card* 841) will help in locating this fast moving comet during the coming month:

EPHEMERIS OF PERIODIC COMET ENCKE

1947		α h m	δ ° ′	Mag.
Oct.	4	6 33.7	+46 46	12.6
	8	7 21.9	47 35	12.0
	12	8 19.3	46 55	11.4
	16	9 21.7	44 3	10.9
	20	10 21.5	38 44	10.4
	24	11 13.0	31 36	9.9
	28	11 55.0	23 44	9.5
Nov.	1	12 27.9	+16 7	9.0

It is still faint but well situated in the morning sky and should reach almost naked-eye visibility in the latter part of November.

With this last addition the list of comets under observation at this time is not less than eight! However most of them are so faint that only powerful instruments can reveal their presence. In order of increasing right ascension at the time of writing they are:

Comet	Mag.
1946 *h* Jones	14
1947 *h* Wirtanen	15
1947 *g* Periodic Whipple	18
1946 *k* Bester	13
1943 *a* Oterma	17
1947 *i* Periodic Encke	15
1947 *f* Periodic Faye	13
1947 *b* Rondanina-Bester	17

The last column gives the brightness estimated by the writer on September 14.

Williams Bay, Wisconsin, September 15, 1947.

General Notes

Mr.Harold A. Lower, of San Diego, California, died in that city on August 12. Mr. Lower and his father did pioneer work in the construction of the Schmidt telescope. They also applied color photography to nebulae. He was an active member in the Amateur Astronomical Society of San Diego up to the time of his last illness.

The President and Fellows of Harvard University have appointed Professor Henry Norris Russell a Research Associate at the Harvard Observatory, beginning with July 1, 1947, which is the date of his retirement from the Research Chair of Astronomy and Director of the Observatory at Princeton. For many years Professor Russell has been a member of the Harvard Overseers Committee to visit the Harvard Observatory and the Department of Astronomy.

New Rapidly Moving Asteroid

Harvard College Observatory Announcement Card 836 contains a communication from the Lick Observatory relating to the discovery of an asteroid by C.

A. Wirtanen. This asteroid has unusually rapid motion, its mean daily motion being 0°.4404, which implies a period of a little more than 800 days. Eros is the only numbered minor planet with a shorter period. The newly discovered asteroid is of magnitude about 15.2.

Perseid Observations at Dearborn Observatory

August 13, 1947. One to two A.M.

Twenty-five members of my summer class in General Astronomy came to the observatory on that morning. There was no moon. The sky was clear. In one hour we recorded 66 Perseids and 12 sporadic meteors. The ratio of 5½ to 1 indicates that the shower is still relatively strong.

OLIVER J. LEE.

Minor Planet Circulars

The International Astronomical Union will issue *Minor Planet Circulars* in order to provide a medium for the rapid publication of observations of minor planets, improved ephemerides, and new discoveries. Arrangements have been made with Dr. Dirk Brouwer, Acting chairman for Commission 20 of the I.A.U., who has found Dr. Paul Herget willing to have the Cincinnati Observatory act as receiving and distributing center.

Observers are requested to communicate to the Cincinnati Observatory their observations with the full accuracy with which they have been measured and reduced, even if it is intended also to publish them elsewhere. The place and the observer should be given as well as the time of observation in Universal Time, expressed in decimals of a day. The right ascension and declination should preferably be reduced to 1950.0. When residuals are given, it is necessary to specify the basis of comparison. Ephemerides must be for the equinox 1950.0 and must specify the basis of the computation: either a reference to the elements or the residuals of the basic observations. Observers are also requested to submit for publication all observations which have been made since about 1940 and which have not been adequately published in well-distributed, accessible publications. Provisional designations will be given to unidentified objects according to the previous custom, but no permanent numbers will be assigned until after this matter has been considered at the forthcoming meeting of the Union.

Circulars will be mailed free of charge by surface mail to all recognized institutions and observers who request this service. Mailing service by air mail to addresses outside the U.S.A., Canada, and Mexico may be obtained by subscribing in advance at the rate of $3.75 for 50 circulars for other countries on the American continents and of $7.50 for all other countries (payable in U. S. currency to Cincinnati Observatory).

The mailing address for all matters pertaining to the *Minor Planet Circulars* is: Cincinnati Observatory, Cincinnati 8, Ohio, U.S.A.

Sir Harold Spencer Jones,
President of the I.A.U.

J. H. OORT,
General Secretary of the I.A.U.

POPULAR ASTRONOMY

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